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THE JOURNAL OF THE AMERICAN WELDING SOCIETY PUBLISHED FOR THE ADVANCEMENT OF THE SCIENCE OF WELDING

VOLUME 16 MAY 1937 NUMBER 5

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ISSUED MONTHLY

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GREETINGS T(AS
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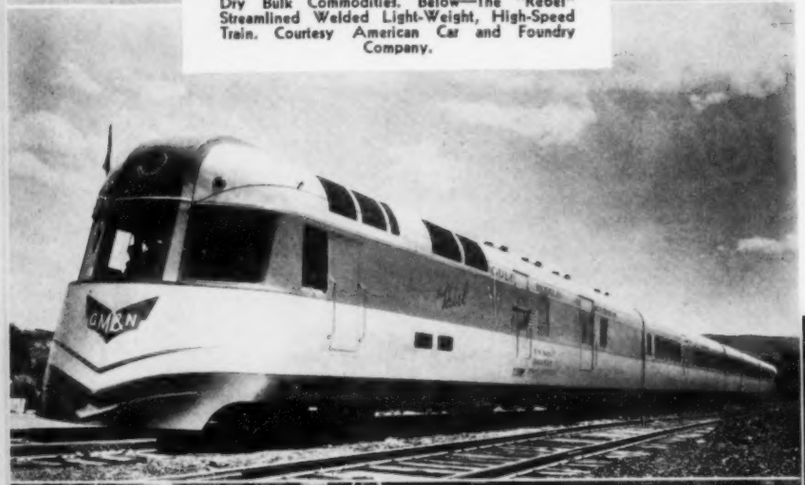
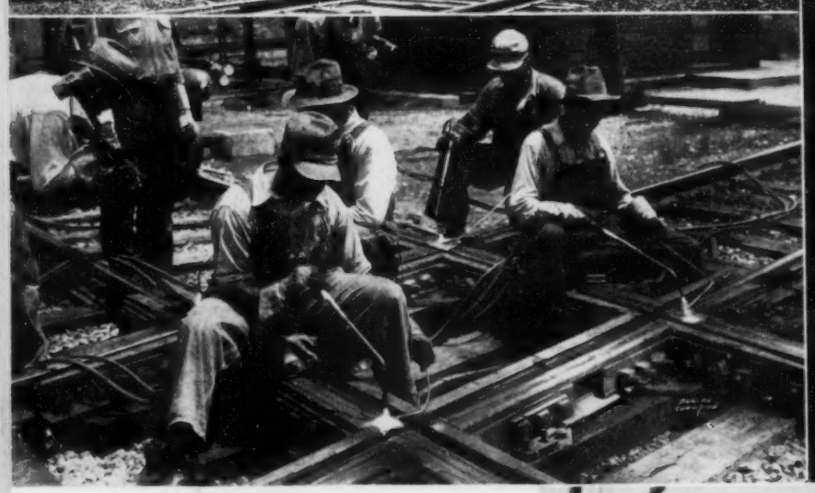
Welding Rides Onw with th

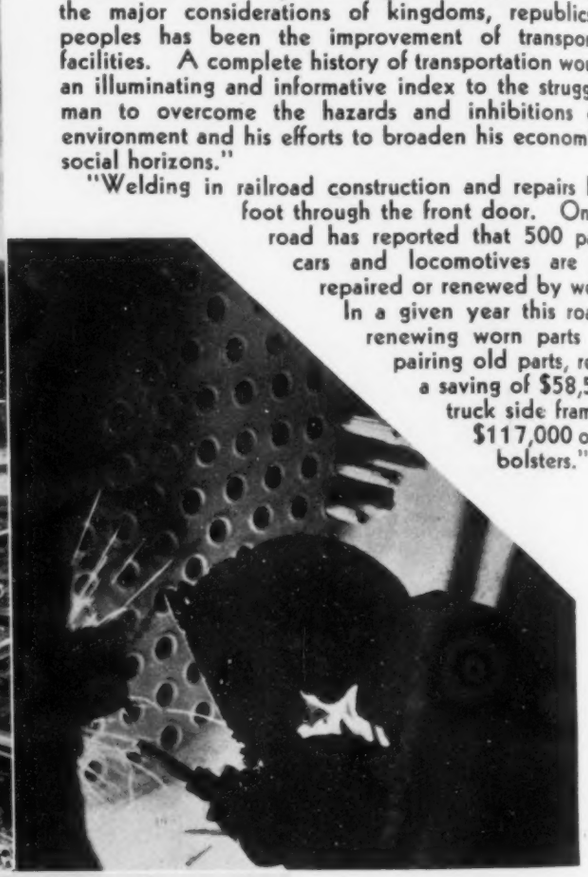
Above—Welded Covered Hopper Car for Dry Bulk Commodities. Below—The "Rebel" Streamlined Welded Light-Weight, High-Speed Train. Courtesy American Car and Foundry Company.



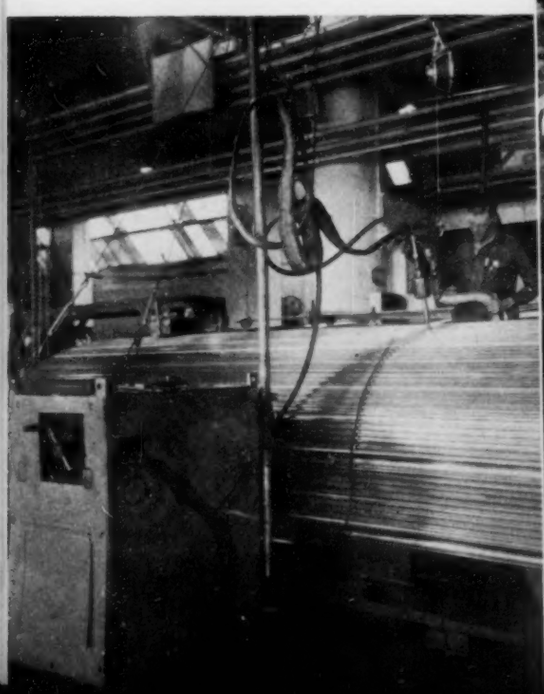
"Transportation has been so necessary to the well being of mankind that throughout all ages and civilizations one of the major considerations of kingdoms, republics and peoples has been the improvement of transportation facilities. A complete history of transportation would be an illuminating and informative index to the struggles of man to overcome the hazards and inhibitions of his environment and his efforts to broaden his economic and social horizons."

"Welding in railroad construction and repairs has its foot through the front door. One railroad has reported that 500 parts of cars and locomotives are being repaired or renewed by welding. In a given year this road, by renewing worn parts or repairing old parts, realized a saving of $58,500 on truck side frames and $117,000 on truck bolsters."



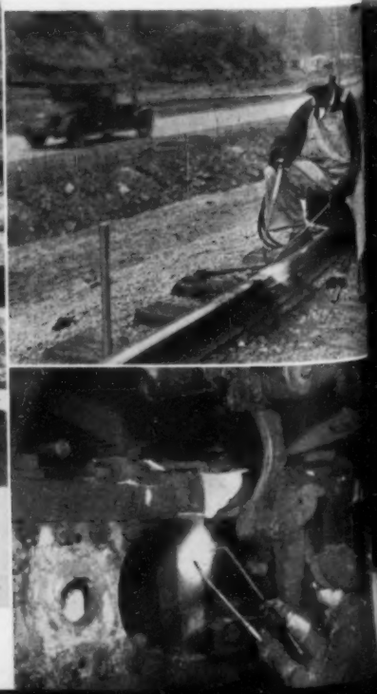


Repairing Railroad Crossing. Courtesy Bastian Blessing Company. Below—"Shotweld" Process Used in Fabricating Stainless Steel Trains. Courtesy E. G. Budd Manufacturing Company



Above—Cropping Rail Ends; Upper Right—Building Up Worn Rail End; Lower Right—Built-Up Locomotive Frame Being Welded. Photos Courtesy Air Reduction Sales Company.

Welding a Flue Sheet in a Boiler. Courtesy Baltimore and Ohio Railroad Company



T(ASSOCIATION
ARAILROADS

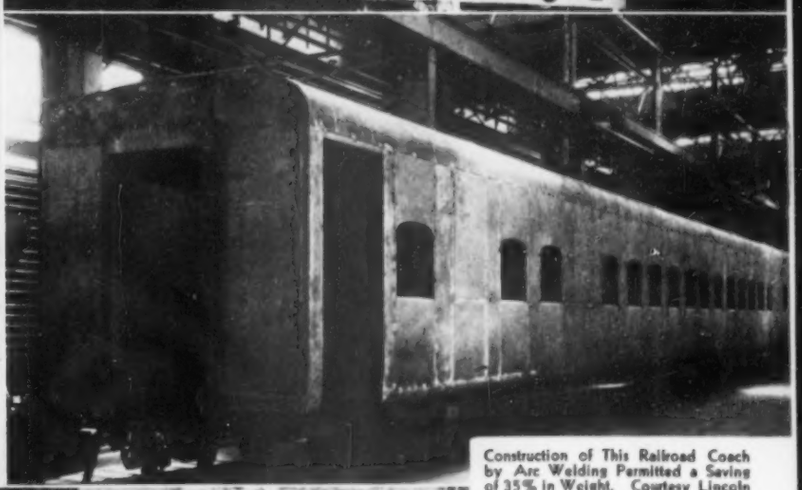
Onw with the Railroads

These are quotations from an address on "Research Results in Railway Transport," by L. W. Wallace, Director of Equipment Research, Association of American Railroads.

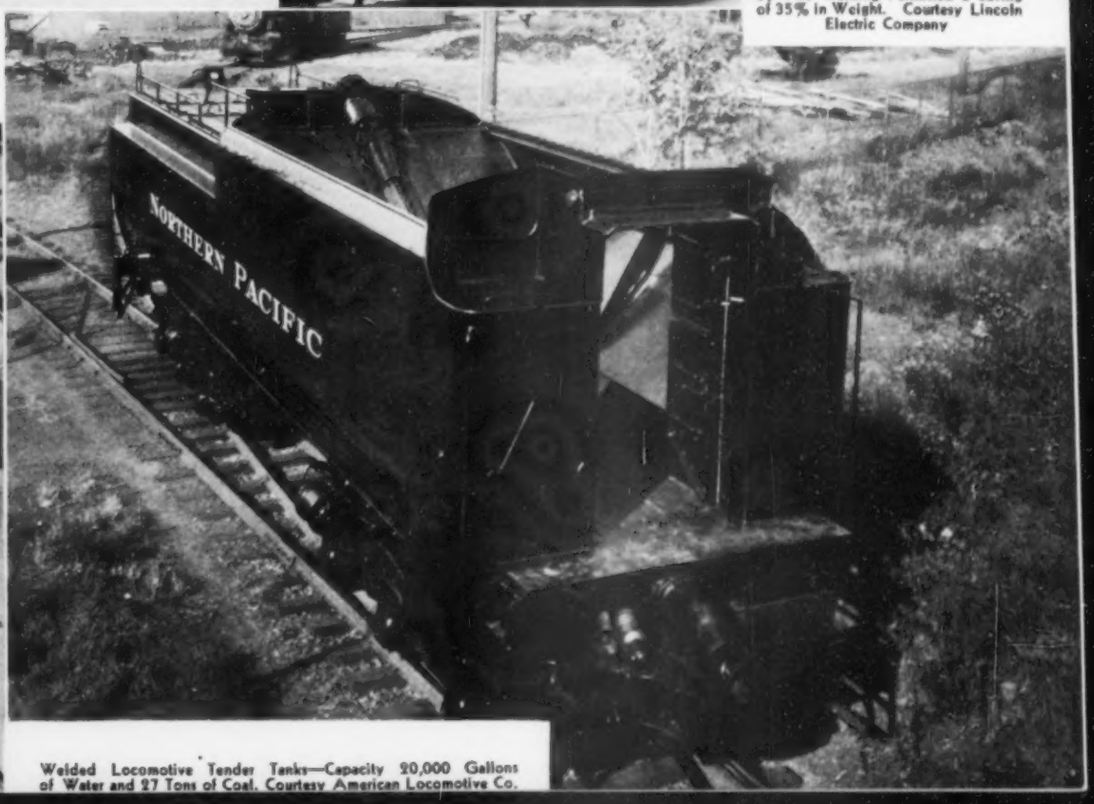
A look at the pictures will indicate that welding is destined to play an important part in the manufacture of 46,000 new freight cars, the 359 steam locomotives and the many new electric, Diesel and light weight trains now on order by the railroads. Welding is saving the railroads millions of dollars annually in its repair and maintenance work. The AMERICAN WELDING SOCIETY extends cordial greetings to the various divisions of the Association of American Railroads and the Railway Supply Manufacturers Association holding their convention in Atlantic City on June 16–23, 1937. It offers cooperation in research, development of new methods, techniques, codes and standards in the welding field.

Welded Steel Underframe for Freight Cars—Bottom Position Turned Upward (Upper Figure). Lower Figure Shows Interior of High Tensile Alloy Steel of Pullman Car Body Frame. Sheets—Spot Welded, Framing Members—Arc Welded. Courtesy Pullman-Standard Car Mfg. Co.

Hiawatha on the Rails Ready to Make Its Regular Run. Welded Cor-ten Steel Effects a Reduction of 1/3 of Total Weight. Below—Welding Rear End of the Hiawatha. Courtesy United States Steel Corp. ▶



Construction of This Railroad Coach by Arc Welding Permitted a Saving of 35% in Weight. Courtesy Lincoln Electric Company



Welded Locomotive Tender Tanks—Capacity 20,000 Gallons of Water and 27 Tons of Coal. Courtesy American Locomotive Co.

Inspection of Welded Pressure Vessels*

By E. R. FISH†

Inspections and Rules

THE inspection of welded pressure vessels falls into two distinct divisions, namely, shop inspection of new work and field inspection of vessels in use.

Shop inspections involve the checking of the material used, the fit-up of the work, the manufacturer's procedure of welding, the skill and care with which welding operators do the welding, the checking of qualification tests of the welders, the witnessing of the final hydrostatic tests and making out the certification papers.

Field inspections involve the determination, as nearly as is practicable, of the soundness of the welding and the competency of the vessel for the pressure it is desired to carry and for the service for which it is used. That field inspection of non-shop inspected vessels is necessary has been proved many times by the numerous failures that have happened because of imperfect welding and defects that have been found before any failure occurred.

While, prior to 1931 the Boiler Code Committee of the American Society of Mechanical Engineers had issued some rules covering welded construction, they were incomplete and not satisfactory. In that year, the Boiler Committee issued its complete rules, including drums for power boilers, for the guidance of those designing and fabricating welded pressure vessels.

It was not until after the development of the coated rod for use with the metallic arc method of welding and rods of the proper metallurgy for gas welding that it was possible to make, on a commercial basis, welds that are strong, ductile and sound. Prior to this development a vast number of pressure vessels were made. Some were good but many were very faulty in both design and workmanship. Hence, the need for careful investigation of pressure vessels produced prior to 1931.

These Codes are now the generally accepted standards of construction and might well be adopted and specified by any purchaser of pressure vessels. These regulations cover materials as well as the characteristics of design and welding. With them or something similar, the inspector has a definite guide.

Classes of Vessels

The A. S. M. E. Code recognizes the different uses to which pressure vessels are put, and accordingly has set-up three classes, as follows:

1. Power boiler drums and U-68 class of Unfired Pressure Vessels which latter includes vessels that may be used for any purpose whatsoever, and without restriction as to thickness of material, pressure to be carried, nature of contents or temperature up to 950° F.

2. The U-69 class covers vessels used for any purpose except for containing lethal gases or liquids, liquids at a temperature in excess of 300°, pressures of over 400 lb. per. sq. in., plate thicknesses exceeding $1^1/_2$ in. and gases in excess of 700° F. temperature.

3. U-70 class of vessels may be used for the storage of gases or liquids, except lethal gases or liquids at temperatures not materially exceeding their boiling temperatures at atmospheric pressure, and at pressures not to exceed 200 lb. per sq. in., and not exceeding a temperature of 250° F.

Specifications with respect to the characteristics of the welding that may be used in the several classes is given in detail in the several Code paragraphs.

Shop Inspections

With respect to new work in the shop, inspections can be made properly only when there are explicit specifications for the guidance of the inspector and detailed drawings showing just how the various parts are prepared, shaped and joined together.

Having familiarized himself with the specifications and checked the design, he should satisfy himself that the materials are of the proper quality and that the various parts are properly fitted up prior to welding. This includes the checking of the preparation of the edges of the plates to be joined.

It is a fundamental principle that the manufacturer must develop, through experimentation and research, a definite procedure by which the welding in the shop is to be done. That procedure should be such as to give weld metal and welded joints with acceptable characteristics, preferably those laid down in the A. S. M. E. Code. It is part of the inspector's duty to have witnessed the demonstration test to prove the sufficiency of the procedure. This procedure should be written out, giving in detail all pertinent data, such as the type of rod to be used, the shape of the welding groove, the number and sequence of the several beads and the current characteristics for electric welding or the size tip and nature of flame for gas welding, etc.

It is the welding operator's duty to be guided by those procedure details for making welds, but prior to doing any work on a pressure vessel, the welding operator must have demonstrated his ability to make sound welds when following the prescribed procedure.

It is the inspector's duty to see that only welders who have duly qualified are permitted to work on pressure vessels coming under his jurisdiction.

While a shop inspector need not be a practical welding operator, he should by all means have sufficient knowledge of the art to judge whether the men doing the welding are reasonably adept at the work.

Tentative rules for the qualification of welding processes and testing of welding operators prepared by the AMERICAN WELDING SOCIETY and which will be adopted in substantially the same form as issued, should be the basis for the foregoing practice.

It is practically impossible to determine by the outside looks of a finished weld what the characteristics of it are, either with respect to the physical properties or the soundness. For power boiler drums and U-68 vessels resort is had to radiographic methods of examination and the inspector must be versed in reading and interpreting

* Presented as Lecture No. 6, at New York Section Lecture Course, Jan. 5, 1937.

† Chief Engineer, Boiler Division, The Hartford Steam Boiler Inspection & Insurance Company.

radiographic films. Radiography has been a very great help in developing methods for producing sound welds, and when the proper technique is used the films give reasonable assurance of the character of the weld.

For U-69 and U-70 vessels, X-raying is not required and unless some other method is used for determining, at least with reasonable assurance, the soundness of the weld, dependence has to be placed on the skill and conscientiousness of the welding operators who do the work and this has been the general practice.

However, it is desirable to have some concrete evidence of the soundness of a welded joint and ways of ascertaining this have been devised.

One method that has been suggested is to cut a slot across the weld and remove a thin slab of metal including the cross section of the weld. Another and more easily applied method is to trepan a plug, by means of a hole saw, from across the weld. This sample can be polished and etched in a 50 per cent solution of hydrochloric acid. This etched specimen gives a good idea of the soundness of the weld and the AMERICAN WELDING SOCIETY rules heretofore mentioned provide a yardstick for acceptability. Several such specimens taken at various points give practically certain assurance of the nature of the whole weld.

Owing to the prohibition in the A. S. M. E. Code against putting unreinforced holes through welded joints, trepanning of holes is not now permissible in connection with the shop inspection of Code vessels. However, the whole matter is in the hands of an AMERICAN WELDING SOCIETY Committee which is studying the problem. The Canadian Interprovincial Rules for Welded Pressure Vessels, about to be issued, will include this method of testing as a required shop operation.

In the case of power boiler drums and U-68 vessels special test plates have to be made with each vessel and these, being tested in the presence of the inspector, give the desired knowledge of the physical properties of the weld metal. In the case of U-69 and U-70 vessels the results shown by the adopted procedure test assure the physical qualities and further tests for that purpose are unnecessary.

Stress-relieving of all power boiler drums and U-68 pressure vessels is required and also for U-69 vessels of certain proportions. It is the inspector's duty to check the temperatures and time of the stress-relieving process and to see that the cooling of the vessel is properly performed. Under improper conditions much harm may be done to the vessel during the cooling process.

Magnaflux is being used by some manufacturers for the detection of incipient cracks on the exterior of welded joints, particularly for thick plates and high-tensile strength alloys but it will not disclose discontinuities at any depth below the surface.

Many non-ferrous alloys are now being used in the construction of pressure vessels, but the same principles with respect to design, construction and inspection, apply as for the ordinary grades of low-carbon steel.

Field Inspection

The field inspection of vessels in use is very much less satisfactory than shop inspection. It is oftentimes difficult if not impossible to determine even what the type of joint may be and an external inspection does not disclose, in any way whatsoever, the characteristics of the weld, either as regards physical qualities or soundness.

More often than not it is impossible to identify the builder of a vessel but, when known, some idea of the design can be obtained by procuring drawings of the vessel to be inspected. Even then the characteristics of the welded joint will still be indeterminate.

Resort should be had to trepanned plugs from vessels in use. It is a relatively simple matter to obtain such samples and a great number have been examined in this way. The inspector can designate the points at which he desires the samples taken and when cut out the holes can be closed by means of a threaded plug or they can be welded shut with specially designed plugs. After having obtained and etched the samples, it can be determined whether the welded joint is or is not reasonably safe.

Lack of fusion, slag inclusion and porosity are the three principal defects. Of these, lack of fusion is by far the most serious. All pressure vessels are subjected to slight changes in shape due to pressure and temperature differentials. These changes are concentrated at the weak points and, if there is a lack of fusion, it is very likely that cracks into the weld metal will gradually develop. This, of course, is an effect in which the time factor is of importance and defects due to this cause are likely to manifest themselves only after a vessel has been in use for a very considerable period of time.

Piping Inspection

The same principles that have been heretofore laid down for pressure vessels are equally applicable to the fabrication of pressure piping, but with one important exception. Welders who are to make welded joints in piping in a fixed position must demonstrate their ability to produce sound welds with the pipe in a vertical position, so that the weld is in a substantially horizontal plane and also with the pipe in a fixed horizontal position so that the weld is in a substantially vertical plane. It requires very much more skill to produce acceptable welds under these conditions than in the simple downhand position. It is the inspector's duty to require sample welds to be made by welding operators who are to be engaged in fixed position welding or to assure himself that the welders employed have satisfactorily made such demonstration welds.

The trepanning method, and, to a limited extent, radiography are ways of determining how sound a welded pipe joint may be. Or, one or more joints can be removed and a complete set of tests made, from which the work as a whole can be judged. It is very desirable that samples be taken from one or more joints of each man's work. Joints found to be not acceptable have to be cut out and rewelded. Furthermore, if the joint examined does not pass, other samples from one or more joints must be taken and if generally non-acceptable, all joints must be cut out and properly rewelded.

General

Trepanning plugs from welded joints of any kind has a tremendous psychological effect on the welding operator. He does not know from what points plugs are going to be taken and in consequence must at all times do his best. Furthermore, the manufacturer is keen to have only acceptable work turned out in order to avoid the penalties that are likely to accompany imperfect work. This kind of inspection stimulates to a very remarkable degree the consistent making of good welds.

An important part of the inspector's duty is to check the design of a welded vessel to make sure that it complies in all respects with the specifications or code under which it is to be built. This involves the shape and thicknesses of heads and plates as well as of stays and braces. It looks easy to just bring two plates together and join them by welds, but there are many complex stresses and welding technique to be taken into consideration, as well as code restrictions, so that proper design must be studied with much care.

Safety in Welding*

By R. B. LINCOLN†

THIS paper deals with the provisions that should be incorporated into specifications to insure safety and also gives some of our experiences as to the welding technique necessary to comply with these requirements. Much of the information is drawn from qualification tests and it is hoped that it will be useful to those who are called upon to pass such tests, and also useful in maintaining the quality of regular construction welds equal to that obtained in the tests.

Welded products have an enviable record as to safety. Many welded buildings have been in use long enough to demonstrate their safety. Many of the bridges in this country have been reinforced by welding. High-pressure boilers, petroleum stills and piping are usually welded, and a nationally known authority stated, a short time ago at one of our meetings, that no pressure vessel made under the American Society of Mechanical Engineers Code had failed due to defective welds.

This record of safety is partly due to forward looking individuals and manufacturers who were more concerned to do a good job than to make a large immediate profit. Engineering Societies and Code Committees have contributed very greatly to promoting safety in welding. They have brought together maker, user and insurance companies and thus evolved balance—workable standards that safeguard quality without stifling progress. This union of minds and the discussion that developed with it have done a great deal to advance our industry. Left to themselves, some of the producers are likely to have too keen eyes on the cost and not look far enough ahead. A very small minority doing poor work could bring discredit on welding. The evil that men do, live after them. The quality of welding is judged by the results of the entire period within the memory and knowledge of the individual.

Actually, it is a good many years since sound, ductile welds were first produced, but it took time for their quality to become fully recognized. The years have built up confidence in welding. Confidence which is of great commercial value because it permits doing a better job at less cost. Fortunately, the individuals who "do not believe in welding" are becoming increasingly rare.

The good record of recent years itself, constitutes a hazard because it is human nature to relax when everything is going good. Eternal vigilance is the price of safety. We must not be in the position of the road superintendent who took down the guard rails because no one had gone over the bank for a long time. I want to briefly point out what guards are necessary and valuable in welding.

One of the first steps should be to specify a suitable

* Presented at April 21st Meeting, Pittsburgh Section, AMERICAN WELDING SOCIETY.

† Director of the National Weld Testing Bureau, a Division of the Pittsburgh Testing Laboratory.

Fig. 4—Defective Nick-Break Specimen

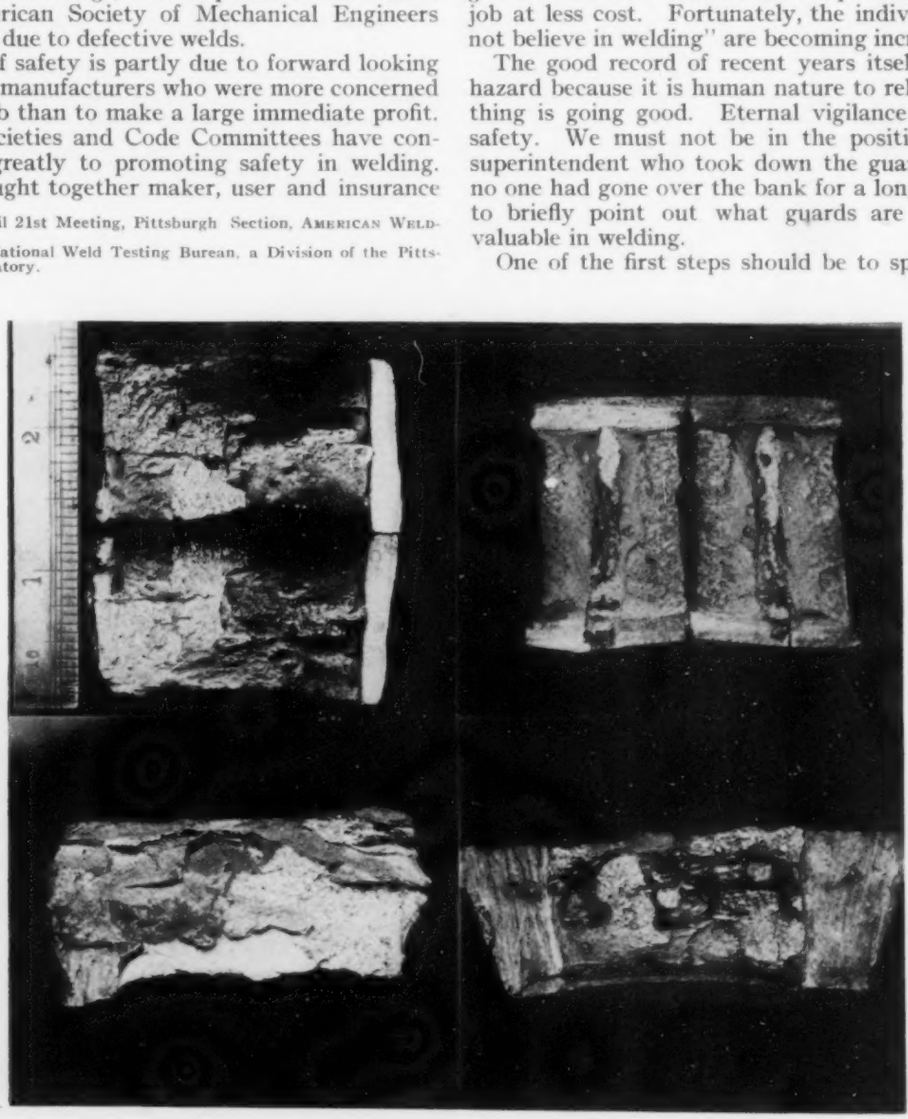


Fig. 2—Chipping Out on Reverse Side Neglected

Fig. 3—Nick-Break Test of a Beginner

Fig. 4—Nick-Break Test of a Beginner

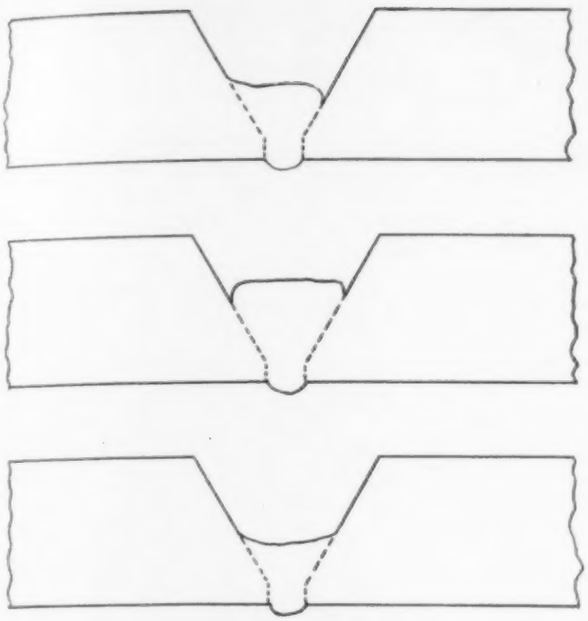


Fig. 5 (Top) and Fig. 6 (Middle)—Weld Bead Deposited with Insufficient Heat
Fig. 7 (Bottom)—Correct Bead Deposit

welding process and qualified welding operators. This can usually be done by demanding compliance with one of the codes or specifications developed by the AMERICAN WELDING SOCIETY, American Society of Mechanical Engineers or other engineering bodies. By adhering to recognized standards, safety is assured and unnecessary repetition of tests is avoided. Some of the codes are very complete, while others leave vital questions to the discretion of the user. Some suggestions as to these questions are given later in this paper.

The AMERICAN WELDING SOCIETY'S Code for Fusion Welding and Gas Cutting in Building Construction is the recognized standard in its line. It briefly lays down rules for design, filler metal, qualification of operators and inspection. It leaves to the judgment of the user the type of filler metal and the length of time that a qualification test shall be effective. It is my opinion that a filler metal producing ductile welds should always be used for buildings and the average welded product. The exact degree of ductility needed will vary with the service conditions of the product, but there are very few applications where a weld of very low ductility is acceptable. If you were designing a building, you would not accept structural steel with elongation values of five to ten per cent, and I feel that there is no better reason for accepting such material at the joints. When no better welds were available, bare wire welds were successfully used by making them so strong that yielding always occurred, if at all, in the parent metal. But now, ductile welds are available at little or no extra cost. In fact, it often happens that the increased speed secured more than offsets the increased cost of the electrodes or welding rod, so that the overall cost is less.

The AMERICAN WELDING SOCIETY has prepared a Tentative Specification for Filler Metal. Several grades with varying physical properties are listed. E-10 covers electrodes and G-10 gas welding rods having free-bend ductility of 30 per cent or better. This material is suitable for the most severe service, such as boilers and pressure vessels. The next grade, namely, E-20 and G-20 required 20 per cent free-bend ductility and is suitable for pressure vessels made under Paragraph U-69 (Class 2). E-20 GP and G-20 GP are general purpose rods, having 20% free-bend ductility and suitable for use in all positions (flat, vertical and overhead). These grades are the ones that I consider suitable for buildings, pipe welding, machinery fabrication, etc.

Two other grades, namely, 30 and 40, have ductilities of 10 and 7%, respectively. I would restrict their use to small and unimportant welds. For example, if you are welding an electric switch box to a column, there will be no harm in using a bare electrode that is classed as E-40 GP. The welds would be subjected to little strain, and in most cases, their failure would not cause serious damage.

To briefly sum up the requirements for safe welded buildings, my judgment would be to require

(1) Compliance with the AMERICAN WELDING SOCIETY Code for Fusion Welding and Gas Cutting in Building Construction.

(2) Filler metal to comply with AMERICAN WELDING SOCIETY Tentative Specification for Filler Metal E-20 GP.

(3) Qualification tests should be made before a neutral party not more than one year before work is completed.

The AMERICAN WELDING SOCIETY'S Specifications for Design, Construction, Alteration and Repair of Highway and Railway Bridges by Fusion Welding has been issued in the past year and is a new addition to the family of rules governing welding. It is particularly interesting because it represents the latest ideas of the leaders of the industry. Of special interest are the rules governing qualification of welders. They represent a departure from the older codes and probably will be used as models for future work.

As I understand the plan, there will be a set of rules governing the qualification of welding process and welding operators for all classes of fusion welding. Codes for a specific product such as building or pressure vessels will simply specify that the welding process and the operators be qualified under these rules. Of course, this does not mean that a man who has been tested on fillet welds for buildings will be qualified to weld pressure vessels, or that a man tested for butt welds in the flat position for pressure vessels will be qualified to make fillet welds in the vertical or overhead position.

A complete set of qualification tests will be given in the general rules but only those applying to the job at hand need to be made. To complete all the tests so that a welder would be qualified to do any kind of work would be unnecessarily expensive and would eliminate too large a per cent of the applicants. Some workmen are excellent in one class of work, but could not pass a test in some other.

The new code for bridges contains as Appendix E, "Applicable Clauses of the AMERICAN WELDING SOCIETY'S Proposed Code for the Qualification of Welding Process and Operators." It states that "The qualification of the process is intended to prove that the material, the equipment, the kind and size of filler metal used, the kind and amount of current, the shape of the groove, if any, and the method of laying and building up the welds, are satisfactory and will produce a welded joint of the prescribed strength and quality. These tests are to be made only once for any process that proves satisfactory, and by a welding operator whom the contractor may select."

The welding process having been qualified by a rather exhaustive test, a simpler and less expensive test is required for qualifying the operators. Or to look at it

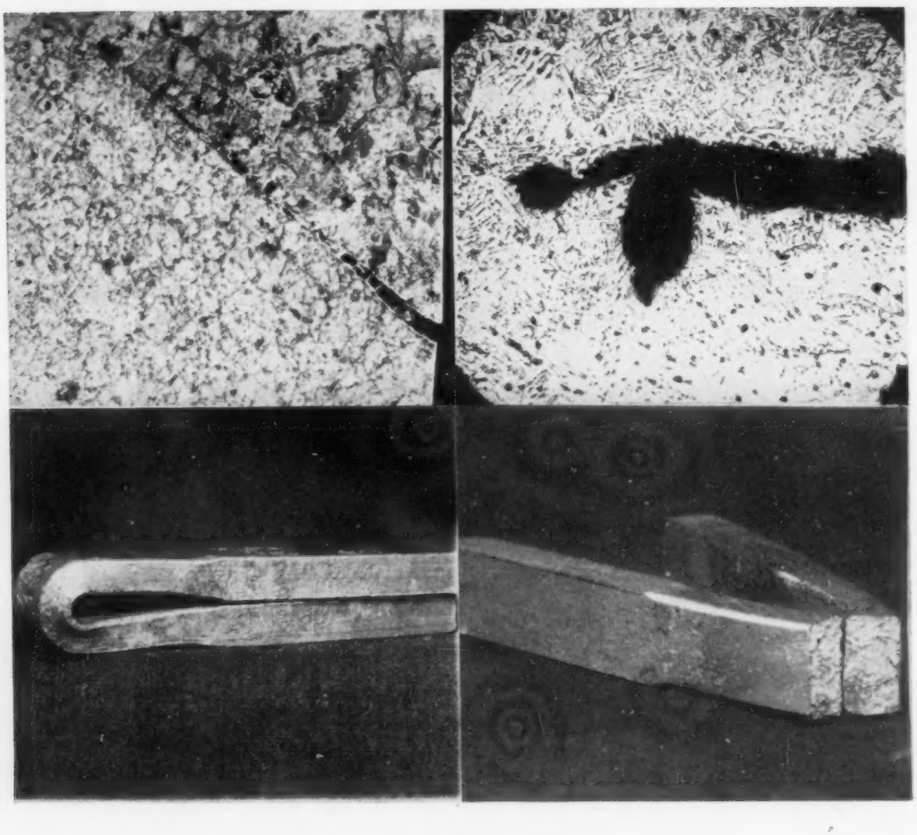


Fig. 8—Bend-Test on a Weld with Cold-Shut. × 10

Fig. 9—Same as Fig. 8. × 50

Fig. 10—Good Free-Bend Specimen

Fig. 11—Bend-Test of a Brittle Weld

another way, qualifying the first operator qualifies the process also and requires the complete test. Additional operators are qualified by fracture and bend tests, without tension tests. If the first tests that qualified the process showed a satisfactory strength, we know that any weld made by the same process will be satisfactory if it is sound. The bend- and nick-break tests serve to determine whether the welds are sound or not. This procedure seems safe because I have noted that the tension specimens seldom fail if the other specimens pass.

The AMERICAN WELDING SOCIETY Specification for Bridges states that "Tests of the process shall be separately required for each of the following types that will be required in the execution of the contract work.

"(1) For fillet welds made in one pass, test for the greatest specified size of leg.

"(2) For fillet welds made in two or more passes, test each different number of passes unless otherwise directed by the engineer.

"(1*A*) For 30–60° fillet welds, made in one pass, test as for 1.

"(2*A*) For 30–60° fillet welds, made in two or more passes, test as for 2.

"(3) For square edge butt welds, test for each required thickness.

"(4) For single "V" butt welds, test for thinnest and for thickest material to be used in the contract.

"(4*A*) For single "U" butt welds, test as for 4.

"(5) For double "V" butt welds, test for thinnest and for thickest material to be used in the contract work; and additionally for each thickness varying by $^3/_8$ inch between the thinnest and thickest.

"(5*A*) For double "U" welds, test as for 5.

"(6) For special welds not enumerated in the foregoing, test each type and size unless otherwise directed by the engineers."

Fortunately, not all of these types of welds occur in the average job. To qualify one welder for all the variables tested except No. 6, special welds, and to cover all welding positions, would require about 125 weld specimens which would be cut up into about 403 test specimens. This is, of course, an extreme case, as it includes both single and double "V" and "U" butt welds and assumes that the engineer will not authorize omission of any position, a right he is given in the specification.

The average bridge job is designed to use fillet welds only. In that case, two butt-strap fillet weld specimens like the Building Code specimens, and two right angle fracture specimens are required for each position. When butt welds are used, a specimen almost identical with that required for the pressure vessel code is used. Twenty-five per cent elongation is required on the free-bend specimen.

Since the AMERICAN WELDING SOCIETY Bridge Specification leaves the number of test specimens to the discretion of the engineer, the invitations to bid, or the general specifications should state specifically what test will be required. Otherwise, one contractor may figure on an elaborate and costly set of tests and another contractor on a simple and inexpensive test.

The tests that I have been discussing apply to the qualification of the process and needs to be done only once. In fact, I don't see any reason why the manufacturer of the filler metal could not do it for all users. If this were done, it would be necessary to specify all details of the welding process such as the number of layers, size of rod, current, etc. It would not be possible to certify that a given filler metal complied with the specification and leave the details of the welding process to the user.

To qualify additional operators, simple and inexpensive fracture specimens are required. If an operator

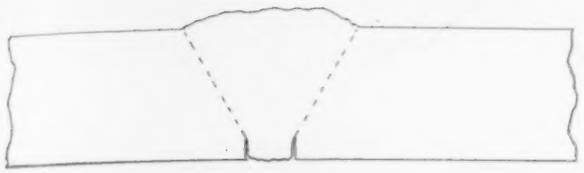


Fig. 12—Slight Lack of Fusion Root Causes Bend-Test Failure

fails, he cannot be immediately retested unless he has made a certain grade in his first test.

The American Society of Mechanical Engineers Boiler Construction Code, The A. P. I.—A. S. M. E. Pressure Vessel Code and The American Standard Association Tentative Code for Pressure Piping are so well known that I will not take your time with an outline of their provisions. All details are covered by the codes. They are so complete that it is only necessary to require compliance with them. I do want to say something about the welding technique necessary to comply with their standards.

All butt welds can be conveniently considered together, regardless of which code applies. They all set a very high standard of quality—one that has been compared to bowling 300. When I first tried to make welds that would comply with the pressure vessel code, and train others for this work, we had so many failures that I was about ready to say, "It can't be done." However, when the correct procedure was once worked out, little difficulty was experienced in making satisfactory welds. I hope to be able to pass on some of the experiences to you and perhaps save others unnecessary experiments.

Many of the illustrations are drawn from qualification tests, because they afford a convenient means of discovering defects. The same defects on regular work might never be discovered. A welder may have had many years of experience and acquired a high degree of skill in making a good looking weld, but still be using methods that will not pass the test. He is surprised and even shocked to learn that his first test has failed.

One of the most frequent causes of failure is a defect in the nick-break specimens. It is our practice to make this test first and if it fails, the cost of machining and testing the other specimens is saved. Figure 1 shows a typical defective nick-break specimen. This has several defects so close together as to be in effect, one defect about $^{3}/_{16}$ inch in length. The maximum length of any defect permitted is $^{1}/_{16}$ inch. Figure 2 shows a much more serious defect. The codes require that for double welded butt joints, the reverse side shall be chipped, ground or melted out so as to secure a clean surface of the originally deposited weld metal prior to the application of the first bead of welding on the second side. This seems to have been neglected or poorly done in this case. Chipping should be done with a gouge having a radius of approximately $^{1}/_{4}$ inch if $^{3}/_{16}$-inch electrodes are to be used for the first bead and for gas welding. A slightly smaller radius can be used for $^{5}/_{32}$-inch electrodes. A diamond point should never be used.

Figures 3 and 4 represent some of the worst nick-break specimens that we have seen. These are the worst of 144 specimens (nick-break, bend and tension) sent to Pittsburgh by a large power company, west of the Mississippi. Of six welders represented, not one passed the code requirements. These particular specimens seem to have been made by workmen with so little skill that the only possible suggestion is for them to learn how to weld. One wonders what would have happened if qualification tests had not been required.

Extremely bad welds are not the rule. Failures like the first ones shown are quite common. A frequent cause of such defect is shown in Figs. 5 and 6.

In this case, there is a deep groove or roll, along one or both sides due to not applying enough heat to fuse that face. The next bead or layer does not fuse to the bottom of this trench. If a defect of this kind occurs for even a fraction of an inch in length, it should be chipped out with a round-nosed chisel before depositing the next layer, both in making tests and in regular work. The ideal way is for each layer to fuse into the sides, as shown in Fig. 7.

Small defects are even worse in the free-bend specimens. Figure 8 is a cross section through a defect that caused the failure of one of these. It is photographed ten times normal size. This defect was in a gas weld made in a pipe, but is typical of a common class in both gas and arc welds. The original defect seems to have been a cold shut about $^{1}/_{8}$ inch long and about $^{1}/_{16}$ inch below the surface. During the bending test, the sound metal between the defect and the surface sheared. As soon as a crack appears $^{1}/_{16}$ inch in length, the test is stopped and the elongation measured. The entire test is condemned for this small defect.

Figure 9 is a portion of this defect magnified 50 times. Examination leads me to believe that the defect was originally caused by drawing the molten metal slightly beyond the edge of the pool with the motion of the welding rod. Liquid metal must be added to liquid metal to make a perfect weld. Where liquid metal is deposited on non-liquid metal a defect results. This type of defect is also produced in arc welding by rolls at the fusion zone illustrated when treating the nick-break specimens. Figure 10 shows a very good free-bend specimen.

Figure 11 shows a different type of failure. In this case the weld snapped but did not show any defects. The weld metal was actually brittle. Our experience would indicate that the usual cause of such a failure, in gas welding, is an oxidizing flame—provided the correct grade of filler metal has been used. An excess of oxygen is so injurious that I prefer to use a slight excess of acetylene where there is no objection to its use. A "feather" about $^{1}/_{16}$ inch longer than the inner cone seems to work well with most welding rods, although there are some rods that tend to boil and produce gas pockets with an

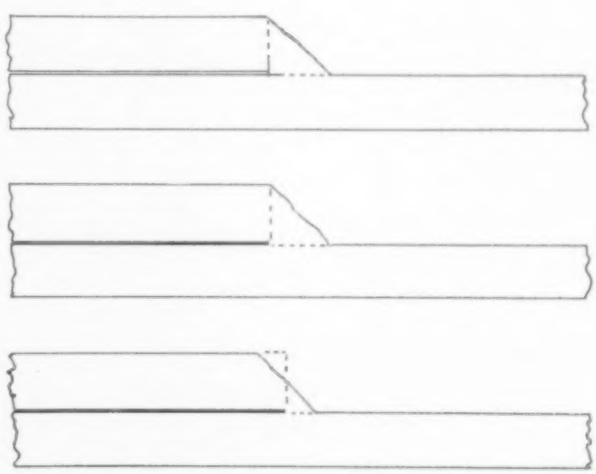


Fig. 13 (Top)—Lack of Fusion at the Root
Fig. 14 (Center)—Perfect Weld
Fig. 15 (Bottom)—An Undersize Weld Obtained by Melting Down Edge of Plate

excess acetylene flame. When a slight excess of acetylene is used, any change is easily seen, while a neutral flame changes but little in appearance when it changes to an oxidizing flame.

Poor regulators, or good regulators in poor condition have caused many poor welds. This is really more serious on regular work than on qualification tests because the poor weld may not be discovered until a serious failure occurs.

The pipe code requires a back-bend test, that is, one bent with the inside of the pipe on the outside of the bend. In order to pass this test, it is necessary to get fusion to the root of the weld. Defective fusion as little as $^1/_{32}$ inch, as shown in Fig. 12, will cause failure. Chill rings or backing strips make it easier to avoid this trouble. When they are not used, a high degree of skill combined with careful work is required to make welds that comply with the code.

Turning to fillet welds, the Building Code requires a total strength of 80,000 pounds on the butt-strap specimen using six inches of $^3/_8$-inch weld. The bridge specification requires 50,000 pounds per square inch, which figures out to practically the same value.

Examining a great number of test specimens shows that many welders do not get fusion in the first $^1/_4$ inch of the weld, this alone represents a considerable percentage of the strength. Many fail to secure fusion at the root, as shown in Fig. 13. An unfused space $^1/_{32}$ or $^1/_{16}$ inch wide is very common here. This represents a loss of about 8% of the strength for one thirty-second and 16% for $^1/_{16}$. In order to pass this test with bare wire, it is absolutely necessary to avoid this defect.

One of the surest ways of getting fusion to the very bottom of the throat with arc welding is to make the weld in two layers. The first one is a small bead in the throat without weaving. It is possible to make a perfect $^3/_8$-inch fillet weld in one layer and this procedure is somewhat less costly than the two-layer method. It is necessary to use a weaving motion that will bring the arc right down into the root. Weaving back and forth along the sloping surface will always leave an unfused line at the root. In other words, you can't get fusion by "absent treatment"—the arc must strike the surface to be fused.

Figure 14 shows a perfect weld and Fig. 15 shows another frequent cause of failure in test specimens. Inspectors should be vigilent to avoid this in actual construction. The defective one has practically the same external appearance as the good one, and looks like it was full size. However, it has been made by melting away the corner of the top sheet and depositing much less metal from the rod than is required for a standard weld. Of course, it can be made at an increased speed, but its strength is correspondingly low. This type of defective weld usually goes with defective fusion at the root because the arc has been applied too much to the upper corner. The strength of a weld having both defects is very low.

The butt-strap fillet weld specimen frequently has very serious magnetic blow. The blow is especially bad at the start of the weld and accounts for failures due to poor fusion at that point This trouble is sometimes helped by placing the work on wood and connecting the ground wire directly to the work. However, there is usually a spot right out on the corner where the magnetic blow will drive the fire right against the corner. Hold the electrode at this point for a moment and get both pieces of steel fused before depositing any metal from the welding rod in order to get perfect fusion at the start.

When a modern coated electrode, or high test gas rod is used, the problem is somewhat different. The standard building code butt-strap fillet weld specimen will fail around 100,000 to 120,000 when welded with this filler metal.

A poor weld may have large defects that cover one-fourth to one-third the fractured area and still go over 80,000 pounds total load, if the filler metal is of the best quality. Such a weld should be rejected, although it complies with the letter of the Building Code.

These suggestions have been made with a hope of improving the quality of welding and thus maintain and promote the safety of welded products. Although much of the data have been secured from qualification tests, it applies to every day work as well. Every weld should be as good as the test welds.

The Fatigue Behavior of Welded Beams as Affected by Shrinkage Stresses*

HIGH welding stresses occur in all welded beams and girders. Although the static strength of girders of good material welded with good electrodes is known to be little affected by shrinkage stresses, their effect on fatigue strength is not so well known.

The important shrinkage stress is that which occurs in the same direction as the design load. In beams the important direction is the longitudinal direction (in the direction of the length of the beam).

In the usual types of welded beams consisting of web plate and two flange plates high tensile stresses occur in the longitudinal welds joining the flanges to the web. In the case of long welded beams, the flange-web welds are the last to be made. If butt welds are made in the web plate or flange plates, additional shrinkage stress are introduced perpendicular to the butt weld, which may be important.

Tests were made on beams in mild steel (static tensile strength = 53,000 psi) either without any butt welds or with butt welds in the flange or web plates. The span was 55 in.; the web was 11.4 in. deep. Commercial coated and covered electrodes (63,000–80,000 psi static tensile strength) were used. The butt welds were made under shop conditions, the ends of the beams being free during butt welding. Beams butt-welded with restrained ends were not tested. Fatigue tests under load acting in the plane of the web showed that the high compressive shrinkage stresses at the ends of the butt welds very favorably affected the fatigue strength. No cover straps at the ends of butt welds are required, the com-

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Summary and conclusions of a report by Dr. Ing. G. Bierett (Federal Materials Testing Bureau, Berlin-Dahlem, Germany). *Ber. Dtsch. Ausschusses für Stahlbau Ausg. B.* Heft 7, J. Springer, Berlin, 1937. 21 pages.

* Translated by G. E. Claussen, Assistant to Fundamental Research Committee.

pressive shrinkage stresses giving natural protection against fatigue failure. The endurance limit of almost all beams was over 28,500 psi (2×10^6 cycles criterion, lower tensile stress 2800 psi) calculated at the tension end of the butt weld. Lower endurance limits were found only for beams with obviously defective welds. In several tests fracture occurred in base metal outside the butt weld.

The weld connecting the tension flange to the web, called the longitudinal weld, seriously lowers the fatigue strength. In butt-welded beams, the butt weld or the intersection of the butt weld with the longitudinal weld was not the main origin of fatigue failure. Instead, failure often started in the longitudinal tension weld on account of poor welding at craters or other irregularities. Fractures frequently occurred where there was a change of cross section. The fatigue strength was not decreased to any extent by tensile shrinkage stresses. Brittle weld metal might have given different results. The fatigue strength depended on the uniformity of the longitudinal weld and on the fatigue strength of all-weld-metal deposited by the electrode. The latter quantity cannot be predicted from the other mechanical properties of all-weld-metal. The fatigue strength of welded I beams without butt welds was 25,700 to 27,100 psi (calculated at the tension edge of the web where fracture originated). For beams with a butt weld in the web or in the tension flange the endurance limit was 24,200 to 25,700 psi. These values correspond to the following stresses calculated at the extreme tension fiber: 28,500 to 30,000 psi, and 27,100 to 28,500 psi, respectively. The endurance limit is based on a criterion of 2×10^6 cycles; the lower stress in all tests was 2800 psi in the outer tension fiber. These endurance limits are of the same order as those developed by the best simple riveted joints (good friction and high clamping force) in direct tension. Whether riveted joints in beams develop equally high fatigue strength is an open question.

The results of this investigation are in agreement with the ideas expressed in the German "Tentative Specifications for Welded Plate Girder Railway Bridges." The results show that butt welds without cover straps are permissible and develop 0.8 times the fatigue strength of unwelded base metal. Some of the tests show that still higher values of the factor for mild steel are safe even in the presence of obvious welding defects. The fact that the butt weld has a lower fatigue strength than base metal is explained by the difficulty in avoiding and detecting defects in thick material and by shrinkage stresses. Butt welds prepared without end constraint are not affected to any extent by the shrinkage stresses, however. A problem remaining for future investigation is the effect of butt-welding beams with constrained ends, which may develop tensile shrinkage stresses in the tensile fibers.

The adverse effect of the longitudinal weld on fatigue strength shows that more attention must be paid to developing suitable electrodes for this type of welding.

Past and Future of Welding in the Pittsburgh District

By G. O. CARTER†

A visit to Pittsburgh is of great interest to me because of the importance of this district in the welding industry and its importance in the development of the welding processes. My first contact with Pittsburgh was twenty-three years ago in connection with the manufacture of steel products, the inspection of which gave me an excellent opportunity to become acquainted with the manufacture and fabrication of steel. This work brought me to Pittsburgh approximately twice a month for three years preceding the War days, and at that time welding and its allied process, gas cutting, was in a formative status, as you can all appreciate.

The War-time need for speeding up the output of material of all kinds gave a very powerful impetus to the use of the oxygen cutting process in foundries where risers had to be removed from steel castings, and, in the cutting of steel billets or their nicking and breaking off in connection with the manufacture of shells for export. Welding was purely a maintenance operation and was employed largely for the repair of broken iron castings. There was practically none of what we call welding engineering today but the art of welding was carried forward by the job welding shops and the maintenance welders within the big mills.

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There were, however, a few industries that were beginning to use welding as a fabricating tool and one of these was a well known Pittsburgh concern, the Blaw-Knox Company. This organization was just getting a good start at that time in the manufacture of water-cooled furnace equipment, and had found that oxyacetylene welding of low-carbon steel gave a finished job that would stand up under the terrific punishment this equipment received when in position in open-hearth furnaces and similar places. The very high quality that was obtainable with oxyacetylene welding was appreciated by this organization, who even then had established very careful control of welding at their plant.

One of the reasons for mentioning the work of this Company is that shortly after the World War we made a thorough study of the problems pertaining to the utilization of welding and cutting. This was done to determine whether the industry was well established after its War-time mushroom development or whether we were on thin ice. Talks with many of those who were operating furnace equipment such as mentioned above, indicated that such welded products, although not always perfect, were standing up better than those made by any other method of fabrication.

Our study also indicated that excellent results were being obtained in maintenance welding in many places.

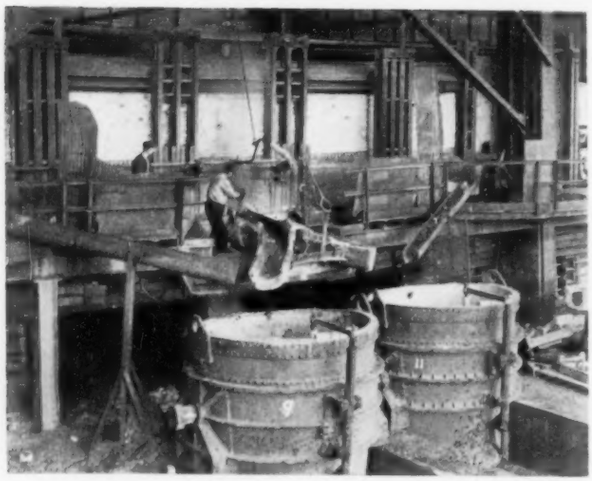

Fig. 1—Tapping Furnace with the Oxygen Lance

However, these results were not general, by any means, and, therefore, it seemed that we should learn what were the best practices and try to cooperate with our customers in applying them. In connection with maintenance welding, we had some extremely interesting experiences in the Pittsburgh area. There we have kept welding service operators busy ever since 1920 and we have seen the staff grow into quite an organization, headed in this region by Mr. Eggers, as you all know.

Among the earliest problems was one on maintenance welding at the Homestead mill. Here the assistant general superintendent was very cooperative in giving us an opportunity to show what could be done although he warned us that the size of most of their equipment placed them in a different category from the average industrial plant. Any one who has gone through one of these big mills and who has stood alongside blowing engines or the steam driven rolling mill engines as used at that time undoubtedly felt almost dwarfed; and can naturally appreciate the magnitude of some of the work that confronted us. We were satisfied with the correctness of our practices, however, and could not see why size should make a great deal of difference.

The basis of undertaking maintenance welding at Homestead was that we would keep two men with them until we had either proved or disproved our statement that a maintenance welding shop under their master mechanic was well justified. Many who are familiar with their operations today know that this mill does have a fine welding organization, so our ideas did prove to be practical. After six weeks the management decided that a welding department should be established. Several years later an inquiry was made as to the effectiveness of this department. It was found that savings due to use of welding over any other method of making the same repairs or replacing the parts amounted to many thousands of dollars per year. Today this kind of a figure would not stagger many of us but at that time it was most impressive.

During this period shortly after the World War, we found that the increase in use of oxygen in certain of the mills was causing the management some concern as they were naturally watching the costs of various supplies. At one mill, orders had been given to reduce the use of oxygen, and when we were discussing some of our process work with the management of the particular plant, this was called to our attention. Our advice was that the important thing was to determine whether oxygen and other welding supplies were being used efficiently and were not being wasted, because if oxygen and acetylene could be used effectively to reduce other manufacturing costs, the growth of the process should not be hampered.

As a result of a study which was then made on the effectiveness of our process, it was ascertained that there were some twenty-five different applications of oxygen or acetylene within a steel plant. This study covered several plants because it was found to be advisable to make studies wherever we were cooperating. At the Homestead mill, which was concededly the largest in the country, there were some 63 different points where the process was being applied in 1920.

You may be interested to know what some of the applications were in this particular plant so a few will be recounted.

Pure oxygen was used for tapping open-hearth furnaces; for tapping blast furnaces; for burning into salamanders, which are the enormous chunks of metal at the bottom of blast furnaces after they have been in use for some time; and for burning into ladle skulls. Pure acetylene was used for emergency illumination; and in combination with oxygen it was used for cutting risers from steel castings, for fabrication of equipment by machine cutting in the machine shop, for cutting done by the riggers in repair work around the steel mills, and for cutting by the millwrights in the removal of cobbled plates or blooms that were jammed in rolling mills.

Welding was used for such maintenance work as repairing cast-iron parts, fabricating equipment made out of low-carbon steel, building gear guards, welding copper tuyères used in the blast furnaces, and many others.

You may, in listening to this list, think that many of these applications are repetitions but that is not the case. The same practices were not followed, for instance, in the opening of a blast furnace tap hole as for tapping an open-hearth furnace, and we made a distinction between the two. However, these two operations were much nearer to being the same than they were to resembling the operation of burning a hole in a salamander. There were very exact steps that were involved in the successful operation of each of these applications, that differentiated one from the other.

In considering the different applications of cutting which have been mentioned, we very properly made a distinction between the manual cutting of steel risers and the machine cutting being done in the machine shop where rotary shears were being fabricated from alloy plates. The cutting in the armor plate department, where material of 12 and 14 in. thickness was being cut as early as 1914, was a materially different operation from that in the machine shop. It is granted, of course, that the basic principles from an engineering point of view are very much the same, but from an operative, an apparatus and a service aspect they were markedly different.

The use of the cutting blowpipe in rolling mill operations was a very splendid example of the economic effect of this new tool. Before its introduction, when an accident would happen with one of the mills that would cause a plate, billet or other hot piece of steel to jam, it would sometimes take hours to remove the nuts from the bolts that held the mill in position, or held it together, so that the broken parts could be replaced or the cobbled steel could be removed. Certain of the mills were rated as having an output value of $1200 to $1500 an hour, and obviously every hour that could be saved meant just such an amount on the tonnage figures at the end of the month, as the mills were running full blast.

According to stories heard at that time there would sometimes be shutdowns lasting 8 to 24 hours due to the

fact that the machines could not be disassembled. After the introduction of the blowpipe it was found that a nut could be cut into from two sides so as not to harm the bolt, and then a wedge could be driven into one of the cuts so as to split the nut in two. At the sacrifice of the value of this nut its removal could be effected in 3 to 5 minutes. It soon proved to be an economical thing to keep a cutting unit ready for action alongside of each of the mills so as to cut down the number of minutes that would be involved in disassembling the mill if any accident occurred, and this interval was soon reduced to a fraction of an hour. The cutting blowpipe could also be used to cut away the hot steel that was left in the mill at the time of the interruption. By doing this the repair to the mill would be made very much faster and it was also much easier than to dispose of the pieces of damaged steel. These would be reduced to scrap size and returned to the charging furnace.

While talking about economics, there is another prominent example of important savings to be mentioned. We understood that the value of a blast furnace at that time was something like $30,000 per day in output, and as mentioned before, practically all of the steel industry's facilities were then in demand. By drilling salamanders with the oxygen lance and blasting the salamanders apart by means of dynamite the time for removing the old material from a furnace was reduced by several weeks from the time formerly required. As you can well appreciate, the site of a blast furnace was a perfect beehive of industry from the time that the furnace was shut down until its lining had been taken down, its base cleaned up and the furnace rebuilt. Those of us who were in touch with operations at that time certainly got a big kick out of that kind of work in proving the effectiveness of our process.

In connection with welding activities we were faced with a great many different problems that were of as much interest as the cutting ones mentioned above. There was a great tendency on the part of welders to undertake the welding of cast iron, particularly of large pieces, without using preheat. There were many aspects to that situation; for example, from the human side of things many of the experienced welders rated their knowledge of welding on their ability to do a good cast-iron job without preheat. This was matching their wits against the problem that you are still fighting after many years, namely, expansion and contraction.

A study of cast-iron welding indicated that there was no reason why welding of cast iron should not be 100 per cent effective under practically all conditions because even in those early days the grade of cast-iron welding rod was materially better than that of the material used in making iron castings. This meant that the weld section could safely be considered to be stronger than the base metal, and that there should accordingly be no cracking through the weld unless the design of the casting was such as to throw excessively high stresses into the zone of the failure. By requiring the preheating and slow cooling of welded castings so that there would be no serious residual stresses the success of the job would be assured. Incidentally, it was learned that through this use of preheat there was a considerable speeding up of the welding operation and economy in gases—enough so that the preheating paid for itself as well as insured the success of the job.

The welding of steel was quite a different matter at that time from the welding of some of the other metals because the only acceptable steel filler material was the so-called "Norway Iron" welding rod. This could never give deposited weld metal stronger than 50,000 to 52,000 lb. per sq. in., the minimum strength of low-carbon steel. In other words, the strength of the weld metal was invariably less than that of the base metal. The ductility of the Norway Iron deposited metal was usually fair but steel welds at that time were not expected to outpull the base metal.

There were of course many who appreciated that there was no way of riveting or bolting low-carbon steel parts together so that the joint would be stronger than the base metal, and welding was, therefore, not in an untenable position from the point of view of strength. The tightness of welded construction was of course in its favor but it was difficult to get welding operators to make welds with Norway Iron rod that were anything like as strong as it was possible to make them. It was considered at that time that 35,000 lb. per sq. in. tensile strength was a good average for a weld. Incidently the then slowly budding electric welding industry was faced with almost exactly the same strength and ductility conditions—in fact the ductility of the welds made with bare wire electrodes was only 5 to 8 per cent at the best. Obviously there had to be a lot of engineering work and training effort expended before the industry reached the place it now occupies.

Among the items that portray the development of welding was the construction of a pipe line 20 in. in diameter at the Homestead Works several years after we had begun our original maintenance work. This welding was undertaken after a very careful study by the Chief Engineer and the Master Mechanic who visited half a dozen installations where welded piping of 10, 12 and 16 in. diameter had been in operation for a few years.

After it was determined that the "rolling welds" as we now call them could be properly made, a test was conducted to see what would be the strength of the "position welds." Much to every one's surprise the sections cut from the bottom of the first of these welds proved to be the best of the specimens cut from that piece of pipe. A little study showed that there was good reason for this. The welding operator was practically compelled because of the overhead welding to use the correct amount of heat

Fig. 2—Cutting Up a Spill Which Occurred When an Open-Hearth Bottom Broke and Let Out 80 Tons of Metal. The Average Depth of the Cutting Was Only 14 In., So an Oxogen Lance Was Not Needed

Fig. 3—Cutting a Good Sized Riser Off a Steel Casting with the Oxygen Lance—Cutting Blowpipe Combination

and no more, whereas with a rolling weld he could use an excess of heat and still make what seemed to be a good weld. When working overhead on the "position weld" with an excess of heat the metal would be so fluid that it would not stay in place. Therefore, the operator would keep the flame reduced to that point where the metal was working in its ideal state.

This pipe line has given splendid service since that time and has proved the efficiency of welded pipe lines because it had no flanges that were expensive to cover originally and expensive to keep covered as a maintenance operation.

A year after that line was built a second line was welded. It had a complete circular expansion bend that was located near the main bridge from the office building into the mill. It is safe to say that many in this audience are familiar with that stretch of piping, although they may not appreciate that it was almost history making in connection with the welding of industrial piping.

From these beginnings, the development of welded piping has been pushed until today it is safe to say that welding of piping is a standard process. Of course, with the increasing application of pipe welding, there have come improvements in filler materials and in the efficiency of heat application with both welding processes. Thus, today, pipe can be joined to give better strength at a very much lower cost of construction than some dozen years ago. Today it is no problem to develop the full strength of steel even up to 100,000 lb. per sq. in.

Another welding operation interesting from a metallurgical standpoint was the welding of copper tuyères through which the air was introduced into the blast furnaces. These pieces weighed several hundred pounds and frequently became badly burned due to the stoppage of the cooling water and exposure of the uncooled copper to the intense heat in the lower part of the furnace. After much study, suitable copper rods were developed and a welding procedure was devised. The tuyères were preheated to a temperature of 600 to 800° F. and then after the welding operation was completed the tuyères were plunged into cold water so as to toughen the copper. This was quite a metallurgical operation but was justified due to the high cost of copper and therefore the value of the tuyères at that time.

There were many interesting little operations too numerous to mention but there comes to mind one of them, which was the building up of very badly battered rail joints on the narrow gage system in the Jones and Laughlin Southside Works. This plant was so busy that the workmen doing the welding seldom had more than 5 or 10 minutes to work at any one time before they would have to step aside to permit a train to pass over the crossing. Naturally the managers of the mill watched such work with a keen eye and when the job was successfully done the process was given additional credit.

Probably one of the most important things in connection with the use of our process has been in the matter of improving the safety of operating furnaces in the mills. In the days when furnaces had to be tapped by use of a bar and sledge there would be occasions when the metal had become chilled in the tap hole and many hours would be required to effect the opening. In the case of either a blast furnace or an open-hearth furnace a serious delay would spoil the metal of the charge but with the blast furnace there was also a possibility that there would be a furnace breakout, one of the most terrible things that can occur anywhere. Upon the introduction of the oxygen lance for opening furnaces, tapping exactly on the minute became an event that furnace operators had prayed for. Countless lives have undoubtedly been saved because of this improvement in tapping practices.

One of the important activities in the Pittsburgh area is the welding of piping, and a few words might be said about this work. From an engineering point of view a great many studies had to be made concerning the strength of manifolds and of fittings made by the use of welding. Due to the fact that a sizable section is removed from the pipe when a large branch is brought into it, the weld must be of a very high grade in order to give a sufficient reserve of strength. The development of welding specifications so as to provide satisfactory construction has been a real achievement both for the engineering and the operating end of the welding industry.

The effect that welding has had in the design and layout of industrial piping installations is very easy to see. A study of a few photographs of modern installations indicates how the engineers take advantage of the streamlining possibilities of welded construction by placing pipes side by side—a practice not possible in the days of flanged joints and the heavy insulation they required. Reduction in size of pipe diameters and the smaller amount of space taken up by piping within plants are quite important items. Reduction in both installation and maintenance costs of welded piping installations over flanged installations are well known.

The subject of this paper calls for some comment as to the future of welding, particularly in the Pittsburgh area, and in this I think that we can safely look for some very interesting activities.

When welding and oxygen cutting first came into use it was customary to fabricate most steel structures by having a considerable excess of metal over what was needed to withstand the service. With steel at two or three cents a pound it did not seem to be important to reduce the weight of steel when welding was substituted for riveting or bolting. The quality of a welded joint that would give tightness and still permit operation at a relatively high stress was not taken advantage of, at least in moderate sized structures, until quite recently. It would seem that the restudy of all structural design so that weights of material will be cut to the requirements of the new welding codes is something that is certain to come and it is only a matter of months, in my opinion.

In fabricating equipment made from alloy steels it has become necessary to keep down the cost by fully utiliz-

ing the strength of the base material and welds. In fact many of us believe that the successful promotion of alloy steel usage is dependent upon the ability to fabricate the material by welding. This is another part of the industry that is certain to grow in the immediate future and requires both welding engineering study and operative procedure.

On account of the efficiency of equipment made by welding it seems certain that welding will soon become the real standard for construction and will be specified for the making of all joints, except where flanges or other mechanical joints must be made where frequent disassembly is to be allowed for. In this regard we should keep in mind that it is possible to use a cutting blowpipe to sever a piece of equipment from a pipe line and then utilize welding for reassembly. Frequently this is the quickest and the cheapest way of handling a repair job.

Of course the combined use of the oxygen cutting process and the welding processes have been utilized in the manufacture of equipment and machinery where rolled steel has been substituted for castings. A combination of high-grade steel castings with rolled steel is not only possible but has been used on occasions to give very desirable finished products.

This leads to one of the possibilities of the future that has some decidedly attractive features, and that is the making of composite structures where weld metal of certain grades is attached to base metal of an entirely different grade. These composite structures can be best identified by considering some examples as we now see them.

Where certain qualities are desired, bronze can be welded onto steel so as to make a much better bearing surface or for protection against chemical action. Bronze can also be used to build up worn places and can then be machined much more readily than would be the case if steel rod were used.

Hard-surfacing materials are being welded onto ordinary grades of steel in order to increase the life of equipment such as used in digging, well drilling, plowing, etc. Around plants where there is a great deal of hot work to be done some of the special facing materials will stand up many times as long as the base materials themselves. The use of the cheapest possible base material faced with the most suitable surfacing alloy is a development that is in its infancy. This will obviously require a great deal of engineering study in order to correctly specify what is to be done, and it will also require a great deal of study of the procedures that must be followed in order to give satisfactory jobs. We must remember that nothing of this kind was possible until the last few years, but this composite construction has been utilized in some really marvelous ways and the possibilities have hardly been scratched.

So far there has been very little mention of metals other than steel and we must consider these metals in the same category with the alloy steels. Use of aluminum, lead, monel metal, bronzes and brasses now involves welding to a great extent and will undoubtedly require welding for practically all fabrication. In connection with the possibilities of composite construction, we must remember that copper and alloys of copper can be fabricated by bronze-welding just as readily and with as great strength of joint as with filler rod of the same composition as the base metal. Steel can also be fabricated by bronze-welding and the possibilities of the use of this method of joining have hardly been appreciated.

Judging from the above it seems obvious that a great deal is to be done before welding is utilized to its fullest extent, and then there are possibilities of utilizing composite types of construction that will be specialized problems beyond the mere joining of the metals. This will require more and more engineering in welding and also more and more specialization in the welding operation. These are not very definite pictures of the future but if you consider carefully the import of these suggestions you will recognize that they are very far reaching.

Structural Welding Mistakes

By MARTIN P. KORN†

Highway commissions and railroads are now using welded bridge shoes made up of plates or rolled slabs. Many that I have examined have a common fault. The vertical fillet welds stop abruptly near top causing a concentration of stresses at those points that may prove serious. Points "*A*" in Fig. 1*A* are an example. One way to avoid that condition is to groove plate *pb* as in Fig. 1*B*, making the vertical welds continuous around top of *pb*, then mill surface. A concentration of stresses is frequently, though unintentionally, brought into welded members by engineers not too familiar with welding design. Fractures begin at those points.

Figure 2 is that of an actual case of a failure on a building contract. Several seat angles shop-welded to the columns snapped off completely during the unloading on the site. Others became fractured at points "*B*". Plainly there was a concentration of stresses at points "*B*". The safe way to weld a seat angle carrying a beam is to return the weld as at point "*C*" in Fig. 2*A*. A simple rule to remember is to "hook all welds at corners where loads are applied."

Figure 3*A* illustrates welded work that is frequently done incorrectly causing eccentricity. Figure 3*B* is the correct way. When welding heavy parts, the center of gravity of welds should coincide with the center of gravity of the member.

Figure 4 shows a welded beam connection in which angles "*D*" represent a common practice, and angles "*F*" the better method. Angles "*F*" permit of better working conditions for applying welds where clearances are a factor. Less welded material is used yet the distribution is better, the section modulus about axis increased, the eccentricity is decreased. The saving in the weld material and the scrap value from angles "*F*" pay for the additional cutting operations they require.

Several other structural welding details frequently overlooked or not considered are briefly presented:

† Consulting Engineer.

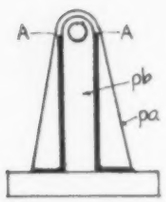

Fig. 1A (Section)

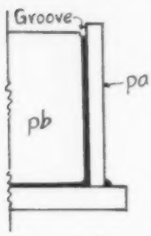

Fig. 1B (Elevation)

(Upper parts of shoes omitted)

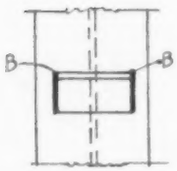

Fig. 2A

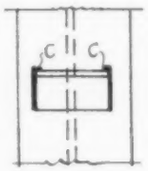

Fig. 2B

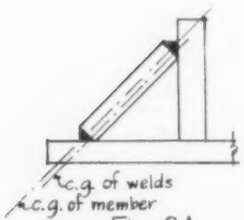

Fig. 3A

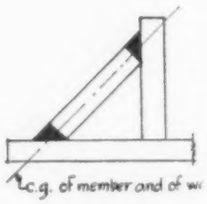

Fig. 3B

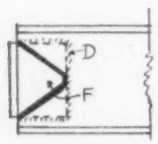

Fig. 4

(1) A combined riveted and welded joint designed for each to take a certain portion of the load is unsafe as the rivets and the welded material will not do team work. The rivets will not work until slippage has occurred in the joint and when slippage has occurred the weld has failed. Welded joints can be made 100% dependable by themselves.

(2) Do not play safe in your designs by piling up weld thicknesses. Such piles, like excess fat, frequently do nothing and cost plenty. (Welding material costs from $2000 to $5000 a ton.) Aside from the excess costs, fractures might result from shrinkage. Designers frequently "play safe" in that manner on the reinforcement of old structures and you see plates welded continuously for long lengths with heavy fillet welds where intermittent welds would suffice for strength, cost less and be completed sooner. A $^1/_8$-continuous weld would provide a seal against water.

(3) A simple rule to gage costs: The cost of fillet welds in place per foot is approximately equal in cents to the size of the fillet in sixteenths squared.

Example: $^3/_8$-fillet equals six sixteenths. Cost equals six squared or 36¢ per foot. $^1/_2$-in. fillet equals eight sixteenths. Cost equals eight squared or 64¢ per foot. (Costs are approximate).

Note the difference in cost resulting from an increase of $^1/_8$ in. in size of fillet.

(4) A carefully designed welded structure is only as safe as the welding contractor who does the job. His selection should not be determined solely by the lowest bid. He plays with your fire and you are not watching him. Put safety first.

(5) A saving in rolled steel and weld metal can frequently result by using bent sections instead of an assembly of shapes. Bent sections heated by welding in the immediate vicinity of a cold bend must be annealed. Sections assembled by welding should be symmetrical in cross section wherever possible. Use H sections in preference to channels.

(6) Welded details should be symmetrical wherever possible to avoid wrong assembly, right and left details, warping from welds. Shop connections once welded are difficult and costly to alter.

(7) Shipping practice sometimes brings impacts not taken into account over the drawing board. Consideration given to shipping might alter a weld detail.

(8) For welding in the field use right hand flat or horizontal welding wherever possible. Welding contractor tries to avoid scaffolding.

The above mistakes and notes are far from all-inclusive. If they serve only as a traffic signal to engineers to stop, look and analyze each welded job individually, better welded designs would follow.

Welded Church

By A. F. DAVIS†

CHURCHES of many kinds serve many creeds, but here illustrated is what is believed the first church of its type ever built. It is constructed of steel, erected and joined together entirely by electric welding.

To build the church, six half circles of steel plate, shaped in the form of the church roof and fabricated by electric welding with trusses like that at front of church, were delivered to the site and placed on the brick foundation. These sections are those at the ends of the church and between the windows. To complete the roof structure, curved steel plates $^3/_{16}$ inch thick and 4 feet wide were electrically welded between and to the large sections. The church was built in Peoria, Illinois by R. G. LeTourneau, Inc. Total cost of the steel work, including designing, fabrication and field erection was only $2000.

† Secretary, The James F. Lincoln Arc Welding Foundation

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"Pipe Welding." The Bastian Blessing Company, 240 E. Ontario St., Chicago, has issued an attractive folder on Pipe Welding, which is a supplement to the Oxy-Acetylene Welder's Handbook issued by the same company. This contains complete information on pipe welding.

Automotive Welding Circular. The Bastian Blessing Company has also issued an attractive circular describing equipment for welding in the automotive field.

Metal Spraying Equipment. The Metalspray Co., Inc., 113 Llewellyn Street, Los Angeles, Calif., has issued an interesting pamphlet giving pertinent data on metal spraying apparatus.

A new welding magazine called "Der Elektro-Schweisser" is being published every two months by Friedr. Vieweg & Sohn, Branschweig, Germany. The magazine is devoted to the problems of the practical welder. The issue for March 1937 (12 pages) contains an article by W. Strelow on Arc Welding, showing designs of joints for tanks, doors and hinges, as well as a lesson on surfacing by welding.

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WELDING SOCIETY ACTIVITIES
AND RELATED EVENTS

American Welding Society Appoints Warner S. Hays Managing Director

A. E. Gibson, *President*, THE AMERICAN WELDING SOCIETY, 33 West 39th Street, New York, N. Y., announces the appointment of Warner S. Hays as Managing Director. Mr. Hays brings to the Society an unusual combination of experience and background in engineering, sales, publishing, membership development and association management. He is a past-president of the American Trade Association Executives, a member of the Philadelphia Rotary Club, The Yale Club of New York and is on the Executive Committee of the Yale Engineering Association. He is also a former officer of the National Industrial Advertisers.

Warner S. Hays

Mr. Hays was born in Cleveland, Ohio. Soon after his birth, the family moved to Scranton, Pennsylvania, where he attended public and high school. Mr. Hays was graduated from Yale Sheffield Scientific School, where he specialized in electrical engineering.

Following his graduation from college, Mr. Hays went to work for the General Electric Company at Schenectady and Pittsfield, spending several years in the Testing and Engineering Departments and acquiring practical experience in the operation of power stations.

Leaving the General Electric Company, Mr. Hays became purchasing agent and assistant general manager of the Interurban and Traction Lines of Rockford, Illinois, and later of the Light, Power and Traction lines of DeKalb and Sycamore, Illinois.

Following his experience in the public utility field, Mr. Hays became circulation and field manager of McGraw Publishing Company in New York. Following this experience in the publishing field, he was preparing for managership of a foreign sales office with the Vacuum Oil Company, but the World War interrupted, and he became an officer in the construction division of the United States Army.

Since the war, Mr. Hays has maintained his own consulting, engineering and association executive office in Philadelphia. He has served many individual firms, the government, and industries on personal relations, reorganizations, association management, advertising and merchandising surveys and has conducted campaigns for technical or engineering as well as trade associations.

Regarding Mr. Hays' appointment, A. E. Gibson, *President*, made the following statement:

"The selection of Mr. Hays as Managing Director of the AMERICAN WELDING SOCIETY is part of the program adopted by the Board of Directors at the annual meeting in Cleveland last October. Through this program it is expected that the Society will be better situated to serve its members and the welding industry. Mr. Hays' work is expected to greatly increase the membership in the Society. During the past six months six hundred new members have been added and several new local chapters established. Within the coming year it is anticipated that the total membership will be increased nearly 100% and the number of local chapters doubled."

"Mr. Hays will lighten the load carried by the officers and members of the Society and will more effectively consumate the Society objectives."

A Letter to the Members of the American Welding Society

This month marks the half-way post in my year as President of your Society. Six months gone and only half as much accomplished as I had hoped for! I suppose that is as it should be; we ought to hitch our wagons to high stars. However, the future looks bright. We have made a fine start and those of us who have been struggling with what at times looked like unsurmountable obstacles, are confident of the outcome.

In the preceding article is told the story of our new Manager, Mr. Hays. I will not comment on him further than to say that he has a fine background and in the few weeks he has been on the job he has convinced me that he knows his "stuff," is a worker, and has the kind of a personality which will bring results.

About two weeks ago some eight or ten of us from Cleveland drove to Youngstown, Ohio, to help Mr. Hays put on a program for 100 welding folks from Youngstown and vicinity, explaining what the AMERICAN WELDING SOCIETY had to offer them. This city is a bee-hive of welding activity. It has every factor necessary for developing into one of our livest Sections, and I am sure we will shortly have one established there.

This week Mr. Hays is in Buffalo, helping the folks there put the finishing touches on the proposed Buffalo Section.

Next week we are holding an open meeting at Erie, Pennsylvania. Mr. Jennings of Westinghouse has consented to come up and tell Erie "How to Weld 29 Metals." We hope to establish a Section there, but possibly not before Fall.

Word has just come to me, and nothing we have accomplished in the past six months pleases me more, that the St. Louis Welding Society has voted almost unanimously to become affiliated with us as the St. Louis Section of the Society. Take my word for it, this Section will show the country what a real live Section should be. Any group which can attract 700 people to a talk on welding is some outfit. That is what they did in February to hear Mr. Jennings. They have arranged their first meeting as an AMERICAN WELDING SOCIETY Section for June 4th, and I am happy to have their invitation to come out and talk to them then.

Here is something that will surprise you. One of the smaller steel producers wrote us a couple of weeks ago, saying that they had heard about our program and would we please accept their contribution of $500 a year. With industry underwriting our new program until we are intrenched, and contributing generously to the work of the Welding Research Committee, there should be no question of the outcome, providing we do our part. Our part means more Sections, more members, a bigger, better Journal, increased committee work on every phase of welding, encouraging technical education in welding, and bringing to industry the results of the fundamental research being carried on so that we may not only increase our knowledge of welding, but may put that knowledge to work.

This week I go to Madison, Wisconsin, to talk to the Welding Conference at the University of Wisconsin. The work being done in welding by these forward looking colleges deserves every encouragement and assistance. Think what turning out

thousands of welding-minded engineers every year will mean to the growth and development of welding. The more fundamental knowledge we can bring into the welding industry, the faster we will travel.

Mr. Hays and I have been invited to attend the welding meeting of N.E.M.A. at Hot Springs, Virginia, on May 17th, to tell them what the Society has done and is planning to do in the future. I welcome this opportunity because we will be among friends who are sympathetic and who want to give us all the assistance they can.

Have you seen our new offices in New York? After years of cramped quarters, the new ones are most welcome. When you westerners from out beyond the Appalachian foothills come to the big city, you must call on our headquarter's staff. You will be welcome, I am sure.

Do you like the splash of color we have put on the JOURNAL covers? A little more time, a few more pages of advertising, another 500 members, and I am sure our editor will show you what a snappy modern magazine he can turn out.

Don't forget your part in all this program—get your new member.

Sincerely,

A. E. GIBSON
President

Board of Boiler and Pressure Vessel Inspectors

The Eleventh General Meeting of the National Board of Boiler and Pressure Vessel Inspectors will be held at the Hotel McAlpin, New York, N. Y. May 24th, 25th and 26th. This Board was organized in 1919 for the purpose of securing uniform approval of specific designs of boilers and pressure vessels through the adoption by various states and cities of one code of rules and of one standard stamp to be placed on boilers and pressure vessels constructed in accordance with such rules.

There will be morning and afternoon sessions on each of the three days. All of the sessions will be open to those interested; registration will be required but there will be no charge.

Major changes in the construction and design of boilers and pressure vessels are being made, together with the development of new materials contemplated in their construction and these changes and new materials are the basis on which the program for this meeting has been developed. The subjects to be discussed are of utmost importance and interest to engineers, manufacturers and operators of these vessels and the papers will be presented by foremost authorities on the various subjects. A partial list of these subjects are as follows:

Welding Problems in Connection with High Tensile Strength Low Alloy Steel.
Use of Non-Ferrous Alloys in the Construction of Pressure Vessels.
Use of Ferrous Alloys in the Construction of Pressure Vessels.
Latest Developments of Steam Generating Plants.
Design and Testing of Safety Valves.
Welding of Power Plant Piping.
The Non-Destructive Inspection of Welded Pressure Vessels.
Developments of Forced Circulation Boilers.
Water Problems in High Pressure Boilers.
Welding of High Strength Copper Alloys.
Operating Problems of Modern Large Steam Generating Units.
General Problems in the Repair by Welding of Boilers, Pressure Vessels and Pipe Lines.
General Problems of Welding in Light of Today's Experience.
Welding of Alloys.
Necessity of Maintaining High Standards for Welded Vessels.
Safe Operation of Low Pressure Steam Boilers and Hot Water Vessels.
Avoidance of Furnace Explosions.

A Special Committee has prepared an exhibit which will be of great interest, showing among other things:

Examples of Sound and Defective Welding.
Examples of Failures Experienced in Operation.
Examples of New Construction and Design of Boilers and Pressure Vessels.

Obituary

RALPH W. BANNAR

Mr. Ralph W. Bannar of Root-Neal & Company, Buffalo, N. Y. died on Monday, April 19th as a result of an automobile accident on Saturday, April 17th. Mr. Bannar was a member of the Society since 1927.

UNIVERSITY OF WISCONSIN WELDING PROGRAM

Thursday, April 29

Mechanical Engineering Building
1500 Blk., University Ave.

Chairman: Prof. G. L. Larson, Chairman, Mechanical Engineering Dept.

8:30 A.M. REGISTRATION

9:15 A.M. OUR ENGINEERING COLLEGE
F. E. Turneaure, Dean, College of Engineering

9:30 A.M. COMBINING STEEL CASTINGS AND PLATE
Harold F. Falk, Engineer, Falk Corporation, Milwaukee, Wis.

10:20 A.M. FLAME HARDENING
(With Demonstration)
Dr. J. V. Slotman, Asst. Manager, Applied Engineering Dept., Air Reduction Sales Co., New York

11:20 A.M. EXHIBITS

Chairman: Prof. R. J. Roark, Mechanics Dept.

1:30 P.M. SAVING BY WELDING
Ernst Wideman, Asst. Chief Engineer, Oilgear Company, Milwaukee, Wis.

2:30 P.M. THE HAZARDS OF ELECTRIC ARC WELDING AND HOW TO GUARD AGAINST THEM. ENGINEERING ASPECTS.

Dr. E. G. Meiter, Director, Industrial Hygiene Laboratory, Milwaukee, Wis., Employers Mutual Liability Insurance Co., Wausau, Wis.

THE HAZARDS OF ELECTRIC ARC WELDING AND HOW TO GUARD AGAINST THEM. MEDICAL ASPECTS.

O. A. Sander, M.D., Milwaukee, Wis., Consultant, Employers Mutual Liability Insurance Co., Wausau, Wis.

Chairman: C. A. Willson, Structural Engineer, State Architect's Office

7:30 P.M. WHAT THE BUREAU OF STANDARDS IS DOING FOR WELDING.

H. L. Whittemore, Chief, Engineering Mechanics Section, National Bureau of Standards, Washington, D. C.

Friday April 30

Chairman: Prof. B. G. Elliott, Mechanical Engineering Dept.

9:00 A.M. SOME FACTORS DETERMINING THE CHOICE OF THE WELDING PROCESS TO BE USED

Louis Larson, Director of Welding Research, A. O. Smith Company, Milwaukee, Wis.

10:00 A.M. COMPARISONS OF HOW WELDS AND RIVETS REACT UNDER PRACTICAL CONDITIONS.

W. S. Kinne, Prof. Structural Engineering, University of Wisconsin

Chairman: R. McA. Keown, Engineer, Wisconsin Industrial Commission

1:30 P.M. SOME METALLURGICAL ASPECTS OF ARC WELDING

J. C. Joublanc, Chief Metallurgist, Harnischfeger Corp., Milwaukee, Wis.

2:30 P.M. WELDING LOW ALLOY HIGH STRENGTH STEELS

A. E. Gibson, *President*, AMERICAN WELDING SOCIETY, President, Wellman Engineering Company, Cleveland

Chairman: Prof. J. W. McNaul, Machine Design Dept.

7:30 P.M. WHY USE FABRICATED STEEL?

J. Gordon, General Manager, Fabricating Division, Taylor Winfield Company, Warren, Pa.

EMPLOYMENT SERVICE BULLETIN

SERVICES AVAILABLE

A-238. Welding Engineer desires position. Have carried out research work in the development of electrodes and metallurgical experiments in the development of welding. Am familiar with all processes. Have welded all the common alloy metals. Have 21 years experience in the welding field. Present age 48.

POSITION VACANT

V-80. Wanted, Experienced welder qualified carbon and carbon molybdenum piping; capable supervising and qualifying other welders. Should be experienced steam power plant piping work all pressures up to 1400 lb. 900 F. Position would be in Orient. State age, qualifications and give full particulars.

Semi-Annual Meeting

The American Society of Heating and Ventilating Engineers will hold their Semi-Annual Meeting, at the New Ocean House, Swampscott, Mass., June 24th, 25th, and 26th, 1937. Members of the AMERICAN WELDING SOCIETY are invited to attend.

Republic Steel President

R. J. Wysor, executive vice-president and general manager, Republic Steel Corporation, has been elected *president* of the corporation, succeeding Tom M. Girdler who will continue as chairman of the board. Mr. Girdler has held both positions.

Mr. Wysor has been active in the steel industry for over 30 years. Starting with the Carnegie Steel Company as a chemist, he subsequently became chief chemist of the Bethlehem Steel Company, Bethlehem; superintendent of the Bethlehem blast furnaces and from there to the position of superintendent of the service division. In 1919 he was made assistant general manager of the Sparrows Point plant. In 1923 when Bethlehem acquired the Cambria Steel Company, Johnstown, Pa., he was made the assistant general manager.

Two and a half years later Mr. Wysor went with the Jones and Laughlin Steel Corporation as assistant general manager. When T. M. Girdler was elected president of Jones and Laughlin in 1929, Mr. Wysor succeeded him as general manager.

Late in 1929 when the Republic Steel Corporation was organized he joined this company as the vice-president in charge of operations, becoming executive vice-president and general manager in September 1935.

Announcing Cincinnati Section

In response to demand of members and of a representative number of other executives interested in welding in the Cincinnati area, a Chapter of this Society was formed on May 7th.

The following officers were elected:

Chairman—W. W. Petry, Cincinnati Milling Machine Co.

Vice-Chairman—William Glennon, Hartford Steam Boiler Inspection & Insurance Co.

Secretary—J. K. Ross, United Welding Co. (Middletown)

Treasurer—Clayton D. Breese, Breese Bros. Co.

These officers were empowered to prepare by-laws, appoint committees, conclude arrangements with AMERICAN WELDING SOCIETY and complete other organization details.

The first activity will be a joint meeting with the Engineers' Club of Cincinnati in an Inspection Trip of Rose Street Generation Station of the Cincinnati Gas and Electric Co. to take place at 8:00 P.M., Thursday, May 20th.

Here will be found the latest application of welding high pressure steam lines and other welding work. Some of turbine valves and piping will not be covered by the 20th, thus giving every chance for close inspection of the welds.

We congratulate those in the Cincinnati Industrial Area in their selection of officers for this new Section and anticipate its becoming one of the leading Sections of the Society.

St. Louis Joins A. W. S.

After several years of effort and negotiation, the St. Louis Welding Society has voted to become the St. Louis chapter of the AMERICAN WELDING SOCIETY. They start off with 33 new members. A letter from the Society is reproduced herewith.

St. Louis Welding Society
4359 Lindell Boulevard

April 30, 1937

AMERICAN WELDING SOCIETY,
33 West Thirty-ninth St.,
New York, N.Y.

Attention: Mr. M. M. Kelly, *Secretary.*

Gentlemen:

Following receipt of your approval of the By-Laws on March 11, 1937, for the St. Louis Section, we submitted the plans of the merger to the members of the St. Louis Welding Society by letter ballot. The merger was approved practically unanimously.

Please consider this letter as the formal application and petition for a charter for the St. Louis Section of the AMERICAN WELDING SOCIETY as set forth in previous correspondence resulting in your approval of the By-Laws for the Section, a copy of which is herewith attached.

Enclosed also, you will please find applications for membership in the AMERICAN WELDING SOCIETY which together with the existing members in St. Louis meets with your section requirements. We are continuing our efforts to increase this number appreciably.

We respectfully request that the remaining formalities in connection with the granting of the charter for the St. Louis Section be concluded as promptly as possible, so that we may install the the newly elected officers and celebrate the founding of the St. Louis Section of the AMERICAN WELDING SOCIETY on June 4, 1937, the first meeting of the coming fiscal year.

Wishing to thank you for the excellent cooperation and courtesies you have extended to us, we are

Yours very truly,
ST. LOUIS WELDING SOCIETY
(Signed) C. W. S. Sammelman
Secretary

Hail the Honolulu Section!

A recent letter applying for a charter of the AMERICAN WELDING SOCIETY was received from Honolulu. Checks for eighteen new members and pledges for twelve additional ones, indicate that this Section will be launched shortly. An organization meeting will be held during the latter part of May.

New Sections in the Making

Youngstown, Ohio held a very enthusiastic preliminary organization meeting on April 15th at the Ohio Hotel. The meeting was presided over by Mr. Grover A. Hughes of the Truscon Steel Company. Mr. Hughes started the evening with an open forum on welding problems, which brought forth a stimulating discussion. President A. E. Gibson was the guest speaker. Mr. E. E. Tross of the United Engineering and Foundry Company reported for the Committee for Organization. Those present unanimously approved the formation of Youngstown Section, including, Warren, Ravenna, Sharon, Grove City, Greenville, Newcastle, Salem, Columbiana and Niles, in addition to Youngstown. At the next meeting to be held in May, Officers will be selected. Mr. R. E. Kinkead, Consulting Welding Engineer from Cleveland will be the speaker.

The Section starts out with 3 Sustaining Members and with the required quota of 25 new Members well surpassed. Over 1150 firms actively doing welding have indicated an interest. The Membership Committee includes Mr. Malcolm Clark, Federal Machine & Welding Co., Chairman; J. J. Moriarity, The Linde Air Products Co., Vice-Chairman; J. B. Blake, Williams Company, Mr. Warrander, Westinghouse Electric & Mfg. Co., R. E. Haas, The Lincoln Electric Company, J. T. Wolfenden, Hobart Company and H. Johnston.

Over 100 turned out at the preliminary meeting. Mr. A. O. Miller, member of the AMERICAN WELDING SOCIETY since 1923, brought a large delegation from the Petroleum Iron Works, Sharon, Pa., as did Messrs. Warrender and Marshall of the Westinghouse Elec. & Mfg. Company. Mr. Tarra of the Chicago Bridge and Iron Company brought a large number from Greenville, Pa. Mr. F. P. McBerty headed the Warren delegation.

A group in Erie, consisting of Messrs. Tsagaris, Burke, Humble, Boyd and Lytton, are arranging for an organization meeting on May 12th. Mr. C. H. Jenning of the Westinghouse Elec. & Mfg. Co., will talk on "How to Weld 29 Metals." President A. E. Gibson will present a greet-

ing from the Society and a brief talk on the advantages of membership. It is expected that by Fall more than 25 "Members" and "Associate Members" will be secured.

The Western New York Section reorganization meeting was held on May 7th at the Hotel Statler, Buffalo. The speakers of the evening were Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corp., whose subject on "Welding Standards" included the Society's new Symbols; and Mr. D. E. Roberts, Engineer, The Linde Air Products Company, who showed some motion pictures on Automatic Flame Cutting. Another lecture in a welding educational series was presented by Mr. Martin P. Korn, Consulting Engineer. It is expected that the Western New York Section will have more than fifty members before the Annual Meeting of the Society.

Other Sections in the making are Indianapolis and Cincinnati.

SECTION ACTIVITIES

BOSTON

The following officers of the Boston Section have been elected to serve for the year 1937–38:

Chairman—P. J. Horgan, General Electric Company
Vice-Chairman—W. L. Warner, Watertown Arsenal
Secretary-Treasurer—P. N. Rugg, Edison Electric Illum. Co. of Boston
Directors (for two years):
P. L. F. Feyling, Whitehead Metal Products Co.
C. A Rober, Bethlehem Shipbuilding Corp.
H. A. Sweet, Assoc. Factory Mutual Fire Ins. Co.
Trustee:
A. L. Combs, Linde Air Products Company
Director of National Society:
H. N. Ewertz, Austin-Hastings Co.

By ballot, Col. G. F. Jenks, Watertown Arsenal, was elected Vice-Chairman, but he resigned as of May 1st, because of transfer orders, and the Executive Committee on April 23rd, elected Mr. Warner to complete the term as Vice-Chairman.

This Section cooperated with the New England Foundrymen's Association, the American Foundrymen's Association, and the Massachusetts Institute of Technology in the first New England Regional Foundry Conference held at Technology on April 9th and 10th. Registration at this conference was 395.

On April 23rd, the last scheduled meeting of the Section for the season was held at Technology, with Mr. Arthur N. Kugler of the Applied Engineering Department of the Air Reduction Sales Company as the speaker. Kugler discussed "Multi-Layer Airco Welding," illustrating his talk with many lantern slides. An actual demonstration of multi-layer welding was given at the conclusion of the talk.

CHICAGO

A most interesting meeting was held by the Chicago Section on Friday, April 16th in the Mission Hall, Armour Institute of Technology. President A. E. Gibson gave a message regarding the AMERICAN WELDING SOCIETY and its activities of interest to all those engaged in the advancement of welding. Mr. George Fred Keck, an Architect, designer of the Crystal House and the House of Tomorrow, at Chicago's World's Fair, spoke on "What Has Welding to Offer the Architect?" Mr. A. S. McCawley of Thomas J. Douglass & Co., spoke on "Welding in the Construction of Building Piping Services."

DETROIT

For its April meeting, held at the Hotel Statler on April 23, 1937, the Detroit Section, AMERICAN WELDING SOCIETY, presented a memorial program honoring the late Professor Elihu Thomson, inventor of electric resistance welding.

Mr. A. E. Hackett, Thomson-Gibb Electric Welding Company, gave a brief review of the life of Professor Thomson and enumerated some of his many achievements. Mr. Francis Jehl, former associate of Mr. Thomas A. Edison, and now connected with the Edison Institute at Greenfield Village, related some of the interesting experiences of his association with the electrical industry. A two-reel motion picture with sound, showing Professor Thomson being interviewed at his home in Swampscott, Massachusetts, was shown. The duplicate of Professor Thomson's original welding machine, built at the Edison Institute for permanent exhibition there, was on display.

The May meeting will be held at the Hotel Statler at 2 P.M., May 19, 1937. This will be a joint meeting with the American Society of Mechanical Engineers, and will be a part of the American Society of Mechanical Engineers Semi-Annual Meeting program. Two papers will be presented. Mr. Everett Chapman, President, Lukenweld, Inc., will speak on "Welded Steel in High-Speed Railway Service," and Mr. C. L. Eksergian, Chief Engineer, Budd Wheel Company, will speak on "Hydromatic Welding of Frames." Chairman of the meeting will be Col. A. S. Douglass, Construction Engineer, The Detroit Edison Company.

KANSAS CITY

The April meeting of this Section was held on the 26th at the Municipal Auditorium in Kansas City. The speaker for the evening, Mr. Harry C. Boardman, Director of Research, Chicago Bridge and Iron Company, gave a most interesting lecture on welding design of tank work as carried on by his company, both in the field and in the shop. The method of operator qualifying tests was explained. Mr. Boardman illustrated his talk with slides showing various erection problems. The meeting was attended by about seventy-five members and guests.

The May meeting will be held on the 17th at which time Mr. L. J. Larson of the A. O. Smith Corporation will present the paper "Some Factors to Be Considered in Choice of the Welding Procedure."

The June meeting is scheduled for June 21st, at which time Mr. L. C. Bibber, Welding Engineer, Carnegie Illinois Steel Corp., will discuss the topic, "Welding Standards."

LOS ANGELES

The regular meeting was held April 15th at the Central Manufacturing District Club Rooms with 50 members and guests present. Dinner was served at 6:30 P.M., after which the meeting was called to order by Chairman Wayne Howard.

Dr. Gordon N. Scott, Pipeline Technologist, formerly American Petroleum Institute Associate at the National Bureau of Standards in Washington, speaking on "Cathodic Protection and Corrosion of Pipe Lines" was first on the program.

A sound motion picture, "The Manufacture of Alloy Steels" was next. This was presented through the courtesy of the Bethlehem Steel Co. and Mr. George Stetter, Metallurgist of the Los Angeles plant.

The current issue of THE WELDING JOURNAL was reviewed by Mr. J. C. Blake, Manager of the Victor Welding Equipment Co.

There being no further business, the meeting was adjourned.

MARYLAND

A joint meeting with American Society of Mechanical Engineers was held at Johns Hopkins University on Friday, April 16th. Two hundred and fifty members and guests of both Societies were present. Mr. Everett Chapman, President, Lukenweld, Inc. of Coatesville Pa. gave a very interesting talk on "Control of Deflections in Welding." The lecture was illustrated by slides.

This was the last regular meeting of the Maryland Section of the AMERICAN WELDING SOCIETY for the spring Season of 1937. The Tellers Committee reported the election of the following officers for 1937–38:

Chairman—Dr. J. W. Miller, Ried Avery Co.
Vice-Chairman—C. M. Underwood, U. S. Navy Yard, Washington, D. C.
Secretary-Treas.—C. N. Hilbinger, T. A. Canty, Inc
Members Executive Committee, 1937–40:
Albert W. Foster, Foster's Welding Shop
James E. Taylor, Black & Decker Co.

MILWAUKEE

The Milwaukee Section reported the following elections for the current year:

Chairman—K. L. Hansen, Harnischfeger Corp.

Vice-Chairman—H. F. Falk, Falk Corporation Secretary-Treasurer—J. J. Chyle, A. O. Smith Corp.

Directors (two years):
Fred O. Volz, Lakeside Bridge & Steel Co.
C. H. Bunch, Koehring Co.
S. H. Smith, Air Reduction Sales Co.

Director (one year) to fill unexpired term of late Mr. Kaiser of The Linde Air Products Co.
G. F. Meyer, Machinery Welder Corp.

MONTANA

At the April 7th meeting two papers were read "Welding as Employed in the Fort Peck Tunnels," by V. H. Byrnes, and "The Relation of the Engineer to the Welder and Foundry Man," by T. B Jefferson.

The results of the Section's Election are as follows:

Chairman—Henry F. C. Rumfelt, Fort Peck

Vice-Chairman—Adolph F. Chaw, Nashua, Montana

Secretary-Treasurer—Allen W. Bates Fort Peck

Section Representative—W. C. Anderson, Fort Peck

NEW YORK

The Annual Meeting of the New York Section will be held on May 11th. Motion pictures will be the feature of the evening. An interesting 2-reel picture, with sound, showing the production of steel from iron ore to finished product, and another film of flame stack-cutting showing new methods for cutting plates in stacks will be shown.

PHILADELPHIA

The regular monthly meeting of this Section was held on April 19th. Mr. T. R. Eichtenwalter of the Republic Steel Corporation, presented a very interesting address on "Manufacture, Uses and Applications of Enduro Stainless Steel." In addition to the lecture, there were moving pictures showing the manufacture and application of many of these stainless steels.

The May meeting will be held on Tuesday, May 18th at 1:30 P.M. The meeting will be devoted to an inspection tour of the General Electric Company Plant at Philadelphia.

PITTSBURGH

The last meeting of the Pittsburgh Section for the Spring Season was held Wednesday night, April 21st in the Roosevelt Hotel. Mr. R. B. Lincoln, Director, National Weld Testing Bureau, a Division of the Pittsburgh Testing Laboratory, presented a paper on "Safety in Welding." Mr. Lincoln's paper dealt with the steps necessary to secure safety in welding, both from an engineering and practical standpoint. He also discussed the Codes and Specifications of the AMERICAN WELDING SOCIETY. Slides were used to illustrate the paper.

Preceding Mr. Lincoln's paper, Mr. A. R. Ellis, President of the Pittsburgh Testing Laboratory, gave a very interesting and enlightening talk on the welding situation in industry today and in the past.

Interesting and lively discussion followed.

SAN FRANCISCO

The April meeting of this Section was held on the 2nd at the Athens Athletic Club in Oakland. Mr. W. E. Emmett, District Engineer of the American Structural Steel Association gave a very interesting talk on the subject "The Welding of Structural Shapes in Buildings and Bridges." Following Mr. Emmett's talk a brief open discussion was held regarding the qualification of welders.

It was decided that the May meeting at which the new officers for the coming year would be installed, would be in the nature of a rally where as many of the old-time welders in the industry as possible would be got together and called upon to tell of their experiences.

A motion picture on the subject of Hard Surfacing presented by the Stoody Company and shown through the auspices of the Victor Equipment Company was next on the program.

Following this a résumé on the more interesting articles of the March issue of THE WELDING JOURNAL was presented by Mr. Brooker, Engineer of the Standard Oil Company of California.

The April 30th meeting was held at The Engineers' Club, San Francisco. The principal speaker of the evening was Lieut. Commander W. McL. Hague, U.S.N., whose subject was "Welding in Ship Construction." The next speaker was Mr. H. A. Storrs, Chief Inspector, East Bay Municipal Utility District, whose subject was "Strain Measurements in Welds."

TENTATIVE PROGRAM EIGHTEENTH ANNUAL MEETING AND WELDING EXPOSITION OF THE AMERICAN WELDING SOCIETY

OCTOBER 18–22, 1937

ATLANTIC CITY, N. J.

Headquarters for Technical Sessions and Committee Meetings—Hotel Traymore

Exposition—Convention Hall

Monday, October 18th

Morning

9:45 A.M. Business Session.

President A. E. Gibson, *presiding*

Report on Society activities by President Gibson.
Report on Welding Research Activities by C. A. Adams.
Tellers' Report on Election of Officers.
Award of Samuel Wylie Miller Memorial Medal.
Award of Lincoln Medal.
Review of Committee and Section Activities by Chairmen.
Discussion.

Afternoon

2:00 P.M. Technical Session.

G. F. Jenks, *Chairman*, Col. Ord. Dept., U. S. Army.
E. Vom Steeg, *Vice-Chairman*, General Electric Company.
Industrial Research Papers under the auspices of Industrial Research Committee

Evening

6:30 P.M. Board of Directors' Meeting.

Dinner followed by meeting.
Review of Society Activities, appointments of committees and officers.
New business.

Tuesday, October 19th

Morning

9:45 A.M. Technical Session.

Charles I. MacGuffie, *Chairman;* General Electric Company.
Otto H. Henry, *Vice-Chairman;* Polytechnic Institute of Brooklyn.

FUNDAMENTAL RESEARCH IN WELDING

A series of papers dealing with fundamental research in welding in the universities.

Afternoon

2:00 P.M. Technical Session.

T. M. Jackson, *Chairman*, Sun Shipbuilding & Dry Dock Company.

J. H. Zimmerman, *Vice-Chairman*, Linde Air Products Company.

FUNDAMENTAL RESEARCH IN WELDING

A series of papers dealing with fundamental research in welding in the universities.

Evening

7:30 P.M. Conference and meeting of Fundamental Research Committee.

H. M. Hobart, *Chairman*, General Electric Company.

This conference is scheduled for university research workers in the fundamentals of welding.

Wednesday, October 20th

Morning

9:45 A.M. Technical Session.

P. G. Lang, Jr., *Chairman*, The Baltimore and Ohio Railroad Company.

E. V. David, *Vice-Chairman*, Air Reduction Sales Company.

RAILROAD SESSION

Afternoon

2:00 P.M. Technical Session.

H. J. Bowles, *Chairman*, Bethlehem Steel Company.

A. F. Davis, *Vice-Chairman*, The Lincoln Electric Company.

FABRICATION—PRACTICAL

Thursday, October 21st

Morning

9:45 A.M. Technical Session.

Everett Chapman, *Chairman*, Lukenweld, Inc.

Milton Male, *Vice-Chairman*, U. S. Steel Corporation.

SYMPOSIUM ON LOW- AND HIGH-ALLOY STEELS

Afternoon

2:00 P.M. Technical Session.

W. M. Mitchell, *Chairman*, Carnegie-Illinois Steel Corp.

J. J. Crowe, *Vice-Chairman*, Air Reduction Sales Company.

SHIPBUILDING

Friday, October 22nd

Morning and Afternoon

COMMITTEE MEETINGS

A complete program will be published in the June issue of the Welding Journal. Acceptances of invitations to prepare papers by some of the foremost authorities in welding assure an interesting and instructive convention.

Only Four More Issues for Award

This is to remind members that there is a special award known as the Lincoln Gold Medal to be presented in Atlantic City this year for the best paper published in the JOURNAL before October 1st and including those papers presented before the Annual Meeting of the Society. If you have not sent in your paper please do so at once in order that it may be scheduled for publication. It is a distinction to have papers published in the JOURNAL become part of the historical record of the development of the art of welding.

Financial Report

AMERICAN WELDING SOCIETY STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS FOR THE PERIOD FROM APRIL 1, 1936 TO DECEMBER 31, 1936

American Welding Society
29 West 39th Street
New York, N. Y.

I HEREBY CERTIFY that the Statement of Cash Receipts and Disbursements for the period from April 1, 1936 to December 31, 1936, presented herewith, is in agreement with the books and records of your Society and compares with the statement of Bankers Trust Co., the depository.

DAVID JOSEPH
Certified Public Accountant

CASH RECEIPTS

Membership Dues	$13,058.00
Journal Advertising	5,136.20
Journal Subscription	1,447.58
Annual Meeting Exposition	1,630.25
Bulletins	586.32
Bound Volumes	94.65
Training Courses	7.00
New York Section Lecture Course	845.00
Structural Steel Welding Reports	14.25
Welded Rail Joint Reports	6.40
Reprints	387.12
Society Emblems	13.00
Building Code Bulletins	29.48
Welding Encyclopedia and Books	110.60
Cut Refunds	518.15
Commissions	.56
Bridge Specifications	769.79
Filing Classifications	.50
Filler Metal Specifications	21.44
Qualification Tests	24.25
Printing Refund	263.25
Postage Refunds	20.59
Committee Expense	66.82
Stationery and Printing	3.83
	$25,055.03
Balance—March 31, 1936	1,895.46
	$26,950.49

CASH DISBURSEMENTS

Section Refunds—Membership Dues	$ 2,509.36
Office Equipment	200.90
Journal—Printing	4,736.37
Editorial	1,458.00
Cuts	752.54
Miscellaneous	235.12
Postage	427.90
Promotion	225.72
Year Book	250.00
Salaries	5,963.83
Rent	965.79
American Bureau of Welding	911.16
New York Section Expense	409.49
New York Section Lecture Course	409.56
Postage	604.52

Stationery and Printing	324.49
Committee Expenditures	276.34
Telephone and Telegraph	181.51
Promotion	29.26
Traveling	58.80
Miscellaneous	406.51
Reprints	290.61
Subscriptions	2.75
Bound Volumes	4.83
Bulletins	40.15
Society Emblems	6.87
Encyclopedia and Books	73.49
Bridge Specifications	458.74
Filing Classifications	32.45
Filler Metal Specifications	72.50
Annual Meeting	1,298.45
	$23,618.01
Balance—December 31, 1936	3,332.48
	$26,950.49

AMERICAN WELDING SOCIETY
STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS FOR THE PERIOD FROM APRIL 1, 1936 TO MARCH 31, 1937

CASH DISBURSEMENTS

Section Refunds—Membership Dues	$ 4,484.74
Office Equipment	338.71
Journal—Printing	7,848.40
Editorial	1,995.00
Cuts	1,224.99
Miscellaneous	306.22
Postage	672.37
Promotion	293.45
Year Book	250.00
Salaries	8,335.25
American Bureau of Welding	1,241.16
Rent	1,327.84
New York Section Expense	588.01
New York Section Lecture Course	442.98
Postage	948.10
Stationery & Printing	709.51
Committee Expenditures	288.01
Index & Binding	130.79
Petty Cash Fund	75.00
Telephone & Telegraph	251.82
Membership Promotion & Activities	300.53
Travel	66.90
Subscription Refund	11.25
Reprints	290.61
Annual Meeting	1,307.08
General Office Supplies & Miscellaneous Items	618.97
Welding Handbook	304.00
Bound Volumes	4.83
Bulletins & Reports	730.45
Society Emblems	8.38
Resale Books	178.54
	$35,573.89*
Bank Balance, April 1, 1937	5,231.34
	$40,805.23

CASH RECEIPTS

Membership Dues	$20,555.66
Journal—Advertising	6,675.25
Subscriptions	4,507.45
Reprints	387.12
Supplement	263.25
Cut refunds	1,042.29
Annual Meeting	1,630.25
Welding Handbook	304.00
Bulletins & Reports	1,956.07
Bound Volumes	195.90
Journals	101.69
Resale of Books	263.60
Society Emblems & Certificates	20.00
New York Section Lecture Course	870.00
Postage Refunds	29.73
Committee Expense	66.82
Stationery & Printing	9.19
New York Section	31.50
	$38,909.77
Bank Balance, April 1, 1936	1,895.46
	$40,805.23

* Of this amount expenditures during 3 month period Jan. 1, 1937 to March 31 amounted to $11,955.88.

Membership Report

Membership Status as of April 1, 1937

	A	B	C	D	E	F	Total
Total Membership April 1, 1936	29	362	956	367	2	50	1766
Gain during year	33	149	386	197	.	16	781
	62	511	1342	564	2	66	2547
Loss during year	..	123	300	142	1	40	606
Total Membership April 1, 1937	62	388	1042	422	1	26	1941
Net change during year	33	26	86	55	−1	−24	175

Membership Status, March 31, 1937

	A	B	C	D	E	F	Total
Boston	..	17	52	21	.	..	90
Canada	..	16	19	9	.	..	44
Chicago	4	52	66	10	.	..	132
Cleveland	12	25	99	58	.	2	196
Detroit	4	12	48	27	.	1	92
Kansas City	..	13	25	11	.	..	49
Los Angeles	1	12	128	17	.	4	162
Maryland	1	6	39	22	.	1	69
Milwaukee	2	6	32	21	.	1	62
Montana	..	..	18	19	.	..	37
New York	11	97	136	39	.	3	286
Northern New York	1	4	23	56	.	11	95
Western New York	..	5	9	3	.	..	17
Philadelphia	11	20	97	17	1	..	146
Pittsburgh	8	28	42	8	.	..	86
Portland	..	1	3	2	.	..	6
San Francisco	2	9	38	23	.	1	73
Society	5	65	168	59	.	2	299
Total Membership	62	388	1042	422	1	26	1941

Yearly Growth of Membership

	A	B	C	D	E	F	Total
Organization, March 1919	62	116	13	25	1	..	217
Annual Meeting, 1920	83	35	25	97	1	..	341
1921	81	192	45	254	1	..	574
1922	50	186	81	277	1	..	595
1923	50	193	121	317	3	..	684
1924	51	203	153	299	3	..	709
1925	51	237	219	303	3	..	813
1926	49	273	258	262	3	..	845
1927	51	310	262	226	3	2	854
1928	47	343	299	210	3	11	913
1929	47	378	360	207	3	21	1016
1930	44	498	476	279	3	43	1343
1931	40	443	615	273	3	50	1424
1932	33	403	639	257	2	40	1374
1933	21	350	613	261	2	37	1284
1934	20	345	692	273	2	43	1375
1935	24	348	892	300	2	48	1614
1936	29	362	956	367	2	50	1766
March 31, 1937	62	388	1042	422	1	26	1941